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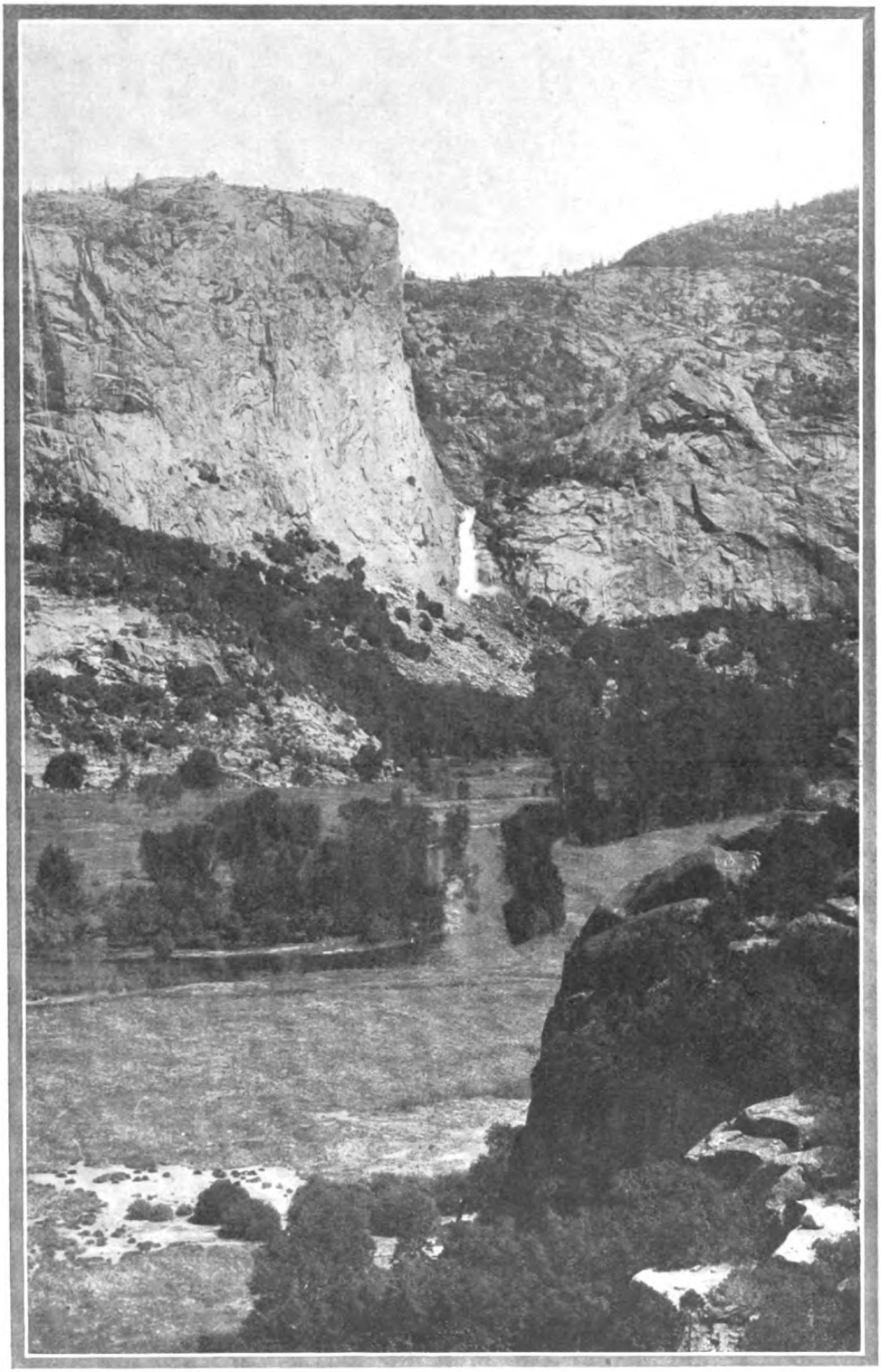

THE HETCH HETCHY DAMSITE, WHERE SAN FRANCISCO IS PREPARING TO STORE WATER THAT THE FUTURE SUPPLY OF THE CITY MAY BE ASSURED.

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EDITORIAL

WE present herewith the first number of *Western Engineering*, a magazine devoted to the West and to Western engineers. We believe the importance of the field justifies the establishment of this journal, and we invite the coöperation of all interested in the upbuilding of the West on a sound basis. *Western Engineering* will be a technical rather than a trade journal, and we shall spare no pains to make it the best in its field.

CONSOLIDATION is the order of the day, and even old-time rivals feel the impulse. A well organized movement has commenced looking toward the creation of a 'Greater' San Francisco by the consolidation of the various cities within the metropolitan district. According to the last census, 'Greater' San Francisco would have a population of 686,873, and would take rank as seventh in the list of cities of the United States. In view of the many benefits that would accrue to all of the cities and towns affected by such a movement, it is surprising that some opposition has developed, particularly in Oakland, which furnishes sleeping quarters for an army of commuters who earn their daily bread in San Francisco. This opposition seems to centre within political circles and perhaps finds explanation in the possible elimination of many comfortable and lucrative offices with the emoluments attached thereto. Apropos of the elimination of offices, it is interesting to note that the tax rate for Oakland, including the city, county, and state taxes, is $3.26 per $100 valuation, while that of San Francisco is $2.05. Petitions are being circulated on both sides of San Francisco bay with the purpose, through the power of the initiative, of compelling action by the state legislature at the coming session.

IN the interesting proposal for new freight-handling docks made in this issue by Mr. G. W. Dickie, it will be noted that provision is made for loading material into the cars through the roof. It has always been surprising that box-cars were not fitted with hatches in the roof; there should be no difficulty in so designing them. Some time ago two box-cars were noticed on one of the wharves from which a large force of men was trying to extract some heavy sugar-mill machinery to be loaded on one of the Island steamships. The time consumed and the number of men on this awkward piece of work must have cost more than the 2000 miles of transportation. As modern appliances become the rule at railroad terminals, the box-cars will all be fitted so that the contents of the car can be reached by cranes and lifted through the roof.

EFFICIENCY is needed in the Government service if anywhere, and we note with approval that General Crozier, Chief of the Ordnance Bureau, has denied the petition of the employees of the arsenal at Watertown, Massachusetts, for abolition of the Taylor system of scientific management. The investigating committee appointed by Congress found, it will be remembered, that "there is no reason why the remainder of the workmen should be

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compelled or induced to work up to the very edge of a breaking strain in order to hold their positions." This result is contrary to the underlying principles of scientific management. The keynote that has been struck thus far by every exponent of the Taylor system has been increased efficiency with a minimum of exertion on the part of the workmen, as well as a scientific grading of the workmen themselves according to the physical requirements of the work to be performed. If workmen are compelled to labor "to the very edge of a breaking strain," the system is so applied as to defeat its purpose. Frankly, we do not believe that any such conditions obtain at Watertown or on any other Government work. This is a question of fact that should be readily determined, but it would appear to be a subject upon which a body of engineers experienced in the handling of men would be better qualified to pass than a committee selected from a political body depending upon the suffrage of the voters for a continuance in office, especially with an election impending.

BONDS are the approved form of security for investors who place safety above interest rate; not that all bonds afford in fact a secure basis for investment, but that as a class they rank decidedly above stocks. Originally bonds were essentially mortgages put in convenient form for sale and transfer. In the main they are still based upon first mortgages on real property. A growing class, however, represents stock in subsidiary corporations, and another consists essentially of promises to pay, guaranteed by some powerful corporation. All have, none the less, some element of security, real or supposed, and some preferment over stocks in the corporations issuing them. The market for bonds is an enormous factor in determining whether engineers shall be busy or idle, since most engineering work depends at some stage upon the sale of bonds. We believe that engineers would do well to study more the relations of construction to finance, and we also believe they should support with their own investments the market for engineering securities. Most engineers must look to their savings for security in their old age, and how better can they invest than in the sounder bonds based upon engineering enterprises? Here the engineer's technical knowledge enables him to discriminate, and at the same time he contributes to the prosperity of his profession. We shall list from time to time new bonds issued to finance engineering work. While not professing to pass expert opinion on the bonds so listed, none will be given space that is not being handled by a reputable bond house and concerning which there is doubt as to legality or soundness. We expect also to publish articles upon the financing of engineering enterprises, and to do what may be possible to spread among engineers sounder ideas as to finance, at the same time that we insist on financiers giving due attention to the engineering phases of new ventures.

Sacramento Valley Reclamation

ELSEWHERE we review in detail the report of the California Débris Commission, in which is recommended a comprehensive plan for reclamation of the Sacramento valley. The proposed expenditure, $33,000,000, is large, but it is estimated that the control of floods will result in the reclaiming for agricultural purposes of about 400,000

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acres of land, now valued at $20 per acre, which when reclaimed should average in value $150 per acre. In addition it will protect over 300,000 acres now reclaimed and valued at $200 per acre. It is estimated that the loss in 41 reclaimed districts in the Sacramento valley during the flood of 1909 was over $4,500,000, while the loss during the flood of 1907 was slightly greater. The losses in the floods of 1904-7 and 1909 amounted to over $11,000,000, and it is generally conceded that in any event large sums must be spent in preventing floods, or in paying flood damage. The economical course is clearly to prevent the floods as far as possible and to minimize the damage from such as are inevitable. The sum necessary is large, but not too large when account is taken of the enormous area and value of the land that is to be reclaimed, and the incidental benefits to navigation and other interests. Expenditures on such work should be measured against benefits, and the mere size of the sum called for should not be held to prohibit an enterprise if it be sound and well considered. That the one under consideration meets both requirements is shown by the consensus of opinion of the engineers and others who have studied the project. The adoption of the by-pass system is a compliment to Mr. Grunsky, Mr. Manson, and the other pioneers who, with much less complete data than is now available, determined its applicability. It is moreover shown to be necessary by all recent experience with great rivers. There will be floods, and surplus water beyond what can be economically provided for through channel rectification, and levees must occasionally be constructed. It is but simple common sense to provide that in such an emergency the water shall travel to the sea along a pre-determined course rather than that it shall be left to chance or levee breakers to fix where the flood shall come.

The report is notable in a second particular. In it, for the first time so far as we are aware, a board of army engineers has recommended that the United States contribute part of the cost of works which are to serve mainly for the reclamation of lands subject to overflow and for the amelioration of flood conditions. Federal funds have been spent liberally in river and harbor improvement, in irrigation enterprises, and on various other forms of public works, but heretofore the reclamation of land by drainage has been left entirely to local initiative. We hope a change in this particular impends. Reclamation of swamp as well as arid lands finds its justification in the making of homes, and anything that will bring the people back to the soil under conditions that assure them success in life, is of most direct national concern. The sum asked from Congress is small in proportion to other demands upon the national treasury and the benefits to the people at large will be out of all proportion to the small size of the appropriation.

Regarding the amount to be provided by the state, it has been suggested that half be raised by a bond issue and the other half by direct taxation on the property benefited. This seems an equitable arrangement. The building of the works would be of indirect but nevertheless positive benefit to every resident of California, and of incalculable value to every resident and property holder within the protected district. The development of the resources of the vast area to be protected and benefited by the proposed works would add millions to the productive wealth of the state, in addition to which it

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would accomplish the primary object of saving to the people the enormous losses that occur annually through floods during the wet season. Practically all of this large amount of money will be spent for labor and material within the state and thus be returned indirectly to the taxpayers. From every point of view the arguments in favor of the prospect are sound.

Engineers and Politicians

RESIGNATION of Mr. W. H. Wiley, who is so closely associated with the movement for pure food and drugs, calls renewed attention to unsatisfactory conditions in the Department of Agriculture. That conspicuously able men should be forced out of the Government service is in itself a serious criticism of the administrative system in vogue. When in addition, as in the case of Messrs. Charles G. Elliott and A. B. Morehouse, men of well attested honesty are dismissed, their reputation blackened, and attempts are made to prosecute them, all for minor violations of department regulations regarding accounts — violations admittedly committed in the interest, and for the benefit, of the Government itself — the matter calls for serious protest. The case of Messrs. Elliott and Morehouse is of especial import to engineers, and we join the *Engineering News* in voicing the protest widespread among engineers. The facts are well known and need not be reviewed. It is also well known, at least to those who have had close contact with the administration of Government affairs, that exact and literal compliance with all the regulations regarding accounts would not only result in enormously increasing the already too great cost of Government work, but would effectually prevent the doing of many things until long past the time when they might be of benefit. As the *Engineering News* has well said, it is a principle in the administration of justice that intentions and results as well as acts shall be taken into account. The punishment of Messrs. Elliott and Morehouse constitutes a miscarriage of justice. It is the act of a shrewd politician attempting to divert attention from the shortcomings of an official superior. Mr. James Wilson has been Secretary of Agriculture continuously since March 5, 1897. At the time of his appointment he was director of the Agricultural Experiment Station of Iowa and one of the few men eminently qualified for the position. He is now nearly seventy-eight years old, and it is an open secret that he long since lost control of his department. His is another of the sad cases of a man who holds to position after his usefulness has ceased, and thereby tarnishes a well earned fame. The Department has grown greatly under Mr. Wilson's administration, but it has not been an orderly growth. Bureaus of relatively little public utility have expanded, and others for which the need is great have starved. Success has been measured too much by influence with Congress, and repeatedly Bureau chiefs have overridden the Secretary and actively lobbied for appropriations against his advice and recommendations. Good men have been crowded out and poor men advanced. The Department has been kept out of partisan politics, but intra-bureau politics has fairly bubbled. Little men, playing the game all of the time, have gathered power beyond their deserts. Thus Mr. George P. McCabe, nominally solicitor for the Department, has come to wield power that has slipped from the feeble hands of the Secretary.

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REVIEW OF THE MONTH

PREPARATION is the keynote of the month. Everywhere the track is being cleared for coming traffic, and nowhere more markedly than on the Pacific coast. Completion of the Panama canal will profoundly change the trade routes of the world, and the public is waking to the fact that this is to be the last year of active construction on the Isthmus. The year 1915 will be celebrated at San Francisco and elsewhere as marking the opening of the canal, but before that boats will pass through, and long before, new ships must be built, harbors improved, warehouses constructed, railway lines and highways lined up and heavily metaled, and in a thousand ways and ten thousand places, preparation must be made. The race is not too swift for the ready.

ACTUAL CONSTRUCTION of the great exposition that is to celebrate the opening of the Panama canal has begun. The long period of paper planning alone is over, and the constructing engineer is now on the job. Contracts for the seawall and for filling a portion of the Exposition site were let in March. Few people appreciate the vast amount of detail work involved in planning a work of this character and magnitude, and still fewer the fact that it is in the designing branch of the engineering department that the most money is lost or saved. It is no belittlement of the work of the construction crew to say that the creation can never be greater than the creator, and changes in plans and specifications once placed into execution may be made only with much difficulty and extra expense. It is well for all concerned that these matters are receiving careful consideration. By going slowly at first, later progress may be made rapid, and the long delay, under which the public has chafed, will, we believe, prove to have been worth while.

PANAMA CANAL work continues with unabated vigor and somewhat better progress was made in February than in the preceding month, in spite of the fact that February was a short month and the rainfall was heavier. The number of yards excavated was 2,643,410, as compared with 2,641,444 in January, while 113,464 yards of concrete was laid, and 418,248 yards was placed in the dams as compared with 476,130 in January. Among other items of interest may be mentioned a macadamized road which will be built to extend over the old Cruces trail from a point where it joins the highway between Corozal and Panama, to Cruces on the Chagres river, a distance of approximately 18 miles. Eight special electric riveting machines, weighing eight tons each, will be employed for the final riveting of the lock gates at Gatun. The cantilever cranes have all been removed from Pedro Miguel lock and transported to Miraflores for use in the lower lock. Hydraulic filling in the east half of Gatun dam has been completed, and the dry fill for the south toe of this wing has been brought to full height for 1000 feet from the spillway toward the locks. Approximately 2,000,000 cubic yards of dry fill remain to be placed. The tug *Reliance* and

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three 600-yard barges are to be sent from the Atlantic to the Pacific side by way of the Straits of Magellan to replace old French equipment which has been worn out. The lumber wharf at Balboa has been completed. A bascule, or balanced-lift span, will be placed in the steel girder bridge where the re-located line of the Panama railroad crosses the Gatun river, half a mile north of Monte Livio. The isthmus continues to be the most interesting place on the continent for the engineers concerned with excavation.

HARBOR IMPROVEMENTS are the order of the day along the entire Pacific coast. Steps are being taken at every important port to prepare for the increase in ocean traffic that the opening of the Panama canal will create. At times San Francisco has been accused of a lack of enterprise, but nothing but admiration can be expressed for the comprehensive plan announced by the State Board of Harbor Commissioners and described in our news columns. Two of the new docks have already been assigned to the American-Hawaiian S. S. Co. and the third to Bates & Chesebrough, the remainder being as yet unassigned. Across the bay Oakland is busy dredging and building, while at Richmond and other points on the great central harbor, important work is under way. Seattle on the north is making elaborate preparations to take care of greatly increased ocean traffic. Plans are complete for the immediate spending of $5,000,000 and an additional $8,500,000 will be available for harbor improvements within the next five years. The enterprise and energy of Los Angeles is proverbial. While San Francisco and Seattle have been blessed with ready-made harbors, Los Angeles has had to labor under the disadvantage of an inland situation. Every difficulty has been overcome and the southern city will be a strong competitor for over-seas traffic. It is announced that the Pacific Mail Steamship Company has plans for a through line of boats from New York to Hongkong and will include Los Angeles as well as San Francisco among the ports of call. That the port offering the best freight-handling facilities will be first to receive consideration goes without saying.

GOOD ROADS are everywhere the mark of a high civilization, and the United States has all too long rested under the stigma of having the worst. Public opinion is rapidly coming to insist upon better highways, both as a matter of economy and for pleasure. The Eastern states have taken the lead in this matter, and excellent work done in Massachusetts, New York, New Jersey, and Maryland has attracted wide attention. When Illinois undertook to demonstrate to the 'standpatters' among her citizens that good roads were not only a desideratum but were technically and financially feasible, Mr. A. N. Johnson, whose experience in Maryland had given him a firm grasp on the subject, was called to take charge of the work. He describes for our readers this month one form of roadbed with which he has been experimenting. Since bitumen and rock are available throughout the Western states the type of construction in question should prove widely serviceable. In California the State Highway Commission is facing the problem of constructing a great system of through routes of the best character, and of getting as much as possible done prior to the flood of visitors expected in 1915. The time of the Commission has been almost en-

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tirely taken during the past month in hearing the claims advanced by delegations from nearly every county in the state. It must be remembered that while $18,000,000 is in itself a large sum of money, it would meet but a small part of the cost if the requests of all the counties were granted. Inevitably many will be disappointed. It has been proposed that the various counties coöperate with the Commission by providing for such bridge and culvert construction as may be required. Some such plan is necessary if the great system of roads contemplated by the statute is to be built. Preliminary surveys taken show the shortest route from the Oregon line on the north to San Diego on the south to cover 940 miles. To this must be added the miles necessary for a coast line and for branches to each county seat.

RAILWAY CONSTRUCTION is not active in the West except in the matter of suburban lines. At the same time there has been a distinctly recognizable letting up of financial pressure, and funds are available for all really necessary work. The day for starving the line, if not past, is going. Twenty-five millions will be spent by the Denver & Rio Grande railroad, according to an announcement recently made by the directors in New York. Of this sum, $2,000,000 will be spent on betterments in Colorado and Utah during 1912, which fact will undoubtedly be hailed with joy by the people of the two states. Bonds are to be immediately issued to the extent of $10,000,000, in order that the funds necessary may be available with the least possible delay. The Western Pacific has been taken in hand by independent bankers, and funds for completing the Sacramento shops, building branch lines, and making many needed improvements are now said to be available. The Southern Pacific Company has many important improvements under way. An interesting item showing the trend toward economy is that the company has applied for a franchise from the Glenn county, California, supervisors to construct the Colusa & Hamilton railroad along the county highway in the river sections for a distance of nine miles, in order to avoid the expense of purchasing a private right of way. There has been a scramble for reorganization before new laws go into effect, and numerous subsidiary companies have been absorbed. The Nevada & California railway has deeded to the Central Pacific Railroad Company its property, consisting of 480 miles of track extending from Hazen, Nevada, to Mojave, California, the consideration named being $1,060,052, the purchaser, in addition, assuming a debt of $8,500,000 in outstanding bonds. Suburban electric railway construction, as shown in our news columns, is active in the San Francisco Bay district, the healthy rivalry between the Southern Pacific and Key Route resulting in improvements in service that will make the commuter a pampered individual, indeed. Residents along the peninsula between San Francisco and San Jose are looking forward to the time when an electric train service will be extended in their direction, as, although it is quite probable that the present amount of traffic would not justify the expenditure of the large amount of money necessary for the conversion of the present steam lines to electric, the change would be immediately productive of a great influx of people and would ultimately make San Mateo county a formidable rival to Alameda in population and importance.

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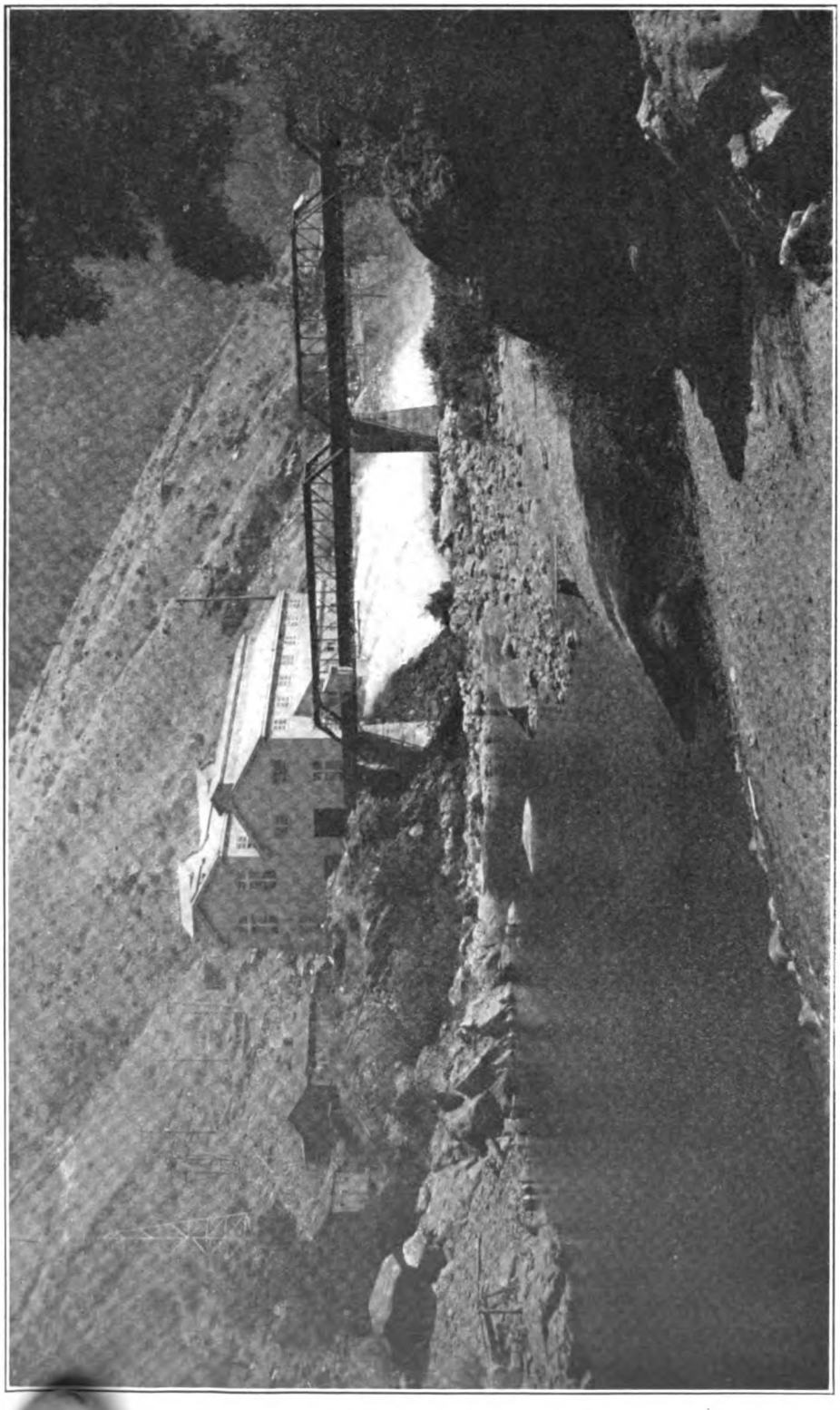

GENERATING STATION OF THE SAN FRANCISCO & SIERRA POWER CO., NEAR ANGELS, CALIFORNIA. FOUR 15,000-HP. IMPULSE WHEELS WITH 8800-KW. GENERATORS DIRECT CONNECTED.

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Developing a Water-Power*

By GEORGE J. HENRY, Jr.†

DURING the past eighteen years the wonderful strides made in perfecting electrical machinery, especially in long-distance transmission, have brought to our doors a force of nature which, while well known since the earliest times, has not until in the past two or three decades become a large factor in the industrial development of civilization. Water-powers in earlier times formed centres around which manufactories invariably grew, as was true, for example, at Lowell and Lawrence in Massachusetts, and Niagara in New York, and the factories, with cheap power, naturally gave rise to villages that later grew into cities of considerable proportions. Similarly, cities have invariably grown where transportation lines naturally centre, as at the mouth of navigable rivers, and, just as railroads, following the lines of least resistance, have given rise to urban centres, canals have not infrequently created an artificial water-power centre. The facility in handling the manufactured product by river or canal, giving cheap transportation combined with cheap power, was probably the principal cause of the industrial superiority of the New England states and New York over the Southern states with their superior natural agricultural resources. Water-powers from the earliest time were applied directly or almost directly to the machinery for which the power was used, and the cost of transportation of the raw material to the factory, and the finished product to the market, naturally confined their use to those most favorably situated with respect to the independently established channels of transportation.

The first complete demonstration of long-distance electric-power transmission, at Frankfort, although of an experimental nature, demonstrated its entire feasibility and focused the eyes of the engineering world on the great possibilities in store for long-distance electric transmission of water-power. A very large amount of work has been done since that time on the design of apparatus, and the process of elimination has brought electric generating units, transformers, insulators, line construction, etc., to a point of unquestioned perfection and reliability. So rapid has been the development in this field that many of the old water-wheel companies have been hard pressed to keep up with the constant demands for water-wheels capable of driving the electric generators in regular and continuous service. The progress of design in water-wheel apparatus has been one of meeting the constantly increasing demand for capacity, working head, speed, and particularly for regulation, affecting principally the first cost, and also the even more essential qualities of efficiency and maintenance of continuous operation—these latter features being necessary to the commercial success of the plant. Most of the water-wheel manufacturing companies were

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not pressed for really scientific results before the advent of electric-power transmission. If the wheels developed enough power to drive the machinery installed, the efficiency or accuracy of speed control was seldom questioned, the user of the power generally being the purchaser and operator of the water-wheel, and frequently the owner of the water-power, or at least a large shareholder in it.

The development of hydro-electric transmission systems has imposed from the first the comparatively new condition of a power company selling electric power to separate and diversified power users at the end of a transmission line or terminal apparatus. This quickly showed the prime necessity for efficiency in order to secure the greatest number of dollars from the power customer in return for the minimum number of dollars invested by the power-development company. However synonymous efficiency and dollars may be to the engineer, to the financier the engineering problem is not germane until it is reduced to dollars.

The variety of purposes for which the power was marketed and the influence of the motors of one customer on the speed of the generating apparatus instantly affected the voltage, the lights, and motors of all other customers, bringing 'kicks' on the line and 'kicks' from the man who was paying dollars to the 'corporation' for the power. This was a source of much annoyance during the experimental period. Speed regulation therefore called for scientific attention, even to a greater degree than had ever been necessary for steam-power plants, and coincident with it, the voltage regulation on the transmission line, with exhaustive study of inductance and capacity, became necessary. As a result, the development of water-power is today on a much higher engineering plane than it occupied twenty years ago.

The modern well engineered water-power plant transforms into effective energy a much greater amount of the theoretical energy in the falling water than does any other commercial prime mover, and, when electrically transmitted and delivered to the customer's apparatus, an output of energy greater by more than twice as much, in proportion to that contained in the falling water is salable, than is delivered by the most highly developed steam-engines and boilers from the energy stored in the coal or oil fuel. With the proper controlling and governing apparatus and reasonable storage facilities, the same economy exists on all-day or all-year loads. This, combined with the fact that there is no charge for fuel, at once justifies much larger investments per unit of power delivered, in the case of hydro-electric transmission plants, than in the case of any other prime mover development.

It is of course legitimate to divide the first cost for purposes of comparison, especially if there are other interests involved in the water rights, and it is probably advisable in most cases, because of the Government's present attitude toward water-power development, that the cost of delivering the water-power to the power-house be segregated. This may readily be seen to be that amount resulting from power actually sold that will take care of the interest, depreciation, and sinking fund necessary to cover the money expended, up to the delivery terminal of the pipe-line. This is almost comparable to the cost of fuel under the boilers, or cost of iron melted under the cupola.

During the past few years the holders

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of water-power rights have come to a full realization of, and unfortunately, sometimes an inclination to overestimate their value. The building of a plant in the mountains costs anywhere from $75 to $1000 per horse-power. This represents an investment of large proportions, which is tied up for several years before it can be put on a really satisfactory returning basis, frequently calling for an initial expense for roads and water rights to provide for a greater power output than the power company can market for a number of years, and during all this time the fixed charges on this partly productive investment are running against the power company. The nature of the investment is also one upon which a much better interest should be returned than that demanded by banks for loans on developed industrials. In other words, investors in the proposed new power enterprise are entitled to a return for the 'venture' and a return for the 'risk' and an interest return on the cash invested. The entire return is made up of these elements, but they are here subdivided to make clear the necessity for allowing a greater return than in some other classes of investment.

Consider first the nature of the 'venture.' It is apparent that if, for example, a loan be made on gilt-edge municipal bonds whose legality has been tested, the risk of loss is remote. If the loan be made to a public-service corporation serving a municipality or engaged in interstate traffic, as railroads or express companies, which are more exposed to municipal, state, or government interference, the risk is slightly greater. The investment, if in a manufacturing company's bonds, is still less secure, and so in each instance the bonds sell at a slightly lower price or guarantee a greater rate of interest. It is also evident that the bonds are not so well protected before the property is developed and put on a paying basis as they are afterward. All these shades of 'venture' increase the returns demanded by capital. It must be borne in mind that in each case it is presumed that the intentions are good and the management entirely honest and satisfactory, and that all the foresight that was possible was employed in the interest of the investor.

But suppose the management becomes dishonest, or, while competent at the commencement, later proves unable to handle the growing business with ability. Suppose earthquake, or fire, or the invention of something that is much better, kills the market for the commodity, or floods, or famine, or some other calamity over which the investor has no control and which he could not foresee, occurs to depreciate the value of his investment, then I say he is entitled to some additional compensation for the degree of 'risk' that he takes.

To recapitulate, I would define the 'venture' as the chance taken by capital on every point that could be foreseen by a financier of average skill, and 'risk' as the chance taken by capital on every point that cannot be foreseen by an average financial mind. The investor who puts money into any power enterprise takes both these chances.

Let us say that **A** has a valuable piece of property on which he can borrow at 5% interest. He mortgages the property to lend to **B**, who is solvent and who gives his note as security at 8% interest. **B** in turn invests the money in a water-power enterprise from which he expects to get 15% return.

A was first receiving interest on his capital (return for his property).

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A is now receiving the equivalent of interest on the capital and a return for the 'venture' in lending it to **B**.

B is taking the 'risk' for the return he expects to receive.

To pursue the problem a little further, suppose now the plant is put in and **B** realizes his expectation of 15% return. He has taken the 'risk' and is entitled to a profit of 7%. **A** is certainly entitled to his 3% for the 'venture' and the 5% for his capital. The same opportunities of investment in the undeveloped plant or enterprise were open to many, but only **B** would take the risk, and only **A** would venture the money with **B**.

If this analysis is a fair statement of the rights of the several parties, then the confiscatory tendencies that seem to pervade many communities which are so willing to array themselves against public-service corporations after a valuable set of assets have been accumulated, but which, while the corporation took the risk, made the venture, and invested the capital, sat comfortably back and allowed, if they did not actually encourage the investments to be made, are certainly not justified and are entirely wrong. It is analogous to the old story of the monkey, the cat's paw, and the chestnuts, in which capital pulls the chestnuts out of the fire, and then the public not only steals the chestnuts but actually beats capital in line that it may continue to do so.

A course of moderation on this subject and an effort on the part of each to understand the other side cannot fail to be beneficial to both sides. This matter has been gone into at some length at the risk of seeming tedious, for surely it should be self-evident, on the matter being given any thought, that the antagonism that seems to be rampant in the land against corporations (principally because they are corporations) introduces a large element of chance with which an investor at this time must reckon, and his only means of protection is to demand a higher return commensurate with the increased risk. It is much more difficult to market securities in view of the feeling that is exhibited by the national, state, and municipal governments, such as is shown by the National Forest regulations, the regulation of waters by state commissions, and the franchise restrictions imposed by municipalities. I am making no argument for capitalistic preference, but a plea for a more clear understanding of those principles which control the development of new or the improvement of existing enterprises, which development and improvement is so essential to the growth and welfare of our American cities, and a clear understanding of which will certainly result in the advancement of civilization at a greater rate than ever before.

The arguments here set forth apply with particular force to the development of water-power. It takes several years to put in a power plant and begin to get returns. The investors must look far ahead and must develop a market for the power they propose to furnish. Bonds must be underwritten and then marketed. No bond house will underwrite the bonds if it cannot see its way clear to market them afterward, and they cannot be readily marketed unless the intending purchasers believe the enterprise will be allowed reasonable liberty; not being hampered, coerced, or discouraged by the interested community or the government. If the bonds are marketed at all under any (or, as at the present time, under all) of these difficulties, then the securities

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will have to be sold at reduced price, making it necessary for the corporation, which would have been a great benefit to the community, either to wait for a more favorable time (the community in the meantime going without light and power or paying excessive rates to a competitor with antiquated equipment) or to sell a much greater par value of securities to raise money enough to proceed. If the latter be done, the consumer of the power or other commodity must pay interest on this increased par value of issued securities.

This short-sighted policy of a large proportion of the public at the present time will not, even if pursued to its maximum, secure from existing corporations a return equal to a modicum of the loss sustained by the public by the retardation which such a policy imposes on the advancement of civic betterment by the proper use of capital.

It is unfortunate that the unusual success of such enterprises as the Standard Oil Company, some railroads, and certain other large enterprises during the past decade should have engendered such an antagonistic public feeling toward corporations generally, for a little thought will show that the interest of the public-service corporation is coincident with the public welfare. The more prosperous a community is, the more it will telephone, the more it will ride on cars, the more houses will use electric light, and the more electric light will be used in each house and on the streets, the more freight will be brought over the railroads, and the more food will be consumed and clothing purchased, and greater will be the resulting general prosperity. It is only during prosperous times that a corporation can develop, and its growth and appreciation is almost invariably the result of prosperity in the community served. The public should be willing to pay the investor reasonable interest for the chance taken, and is entitled to expect and demand a service commensurate with the money paid, but should not expect more than this.

The present tendency to limit franchises, if not carried to too great an extreme, should not be a material deterrent to capital, but if they be limited for a definite period, it should be long enough to permit the financing of the property on advantageous terms. A plan which is receiving favorable attention from many quarters is that of reserving the right to take over the corporation property at any time after due notice has been given, and on terms that are definitely predetermined, and that allow the corporation an adequate return for its investment, including full compensation for the chances taken. It is my belief that some such method will prove the solution of the present unsettled condition which is holding back capital to a great extent, and that the public is beginning to see the justice of such a course.

The market for the proposed power is a factor of the utmost importance, as upon it depends the realization or defeat of the enterprise, however well the plant may be engineered in other ways. The cost of power in the territory to be supplied, the amount of power already available, the cost of fuel and its probable fluctuations in the future, the probability of competition, all these should be studied with the greatest care. The question of competition is a most serious one. Most companies finance their bonds on a 20 years basis, but in the case of a company which built a plant 10 years ago, the apparatus would now be almost out of date, and it would probably be advantageous to replace the 10-year-old equipment with a much

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more modern one with larger capacity units, and scrap the old plant for the saving that would be effected in operating and fixed charges. A power plant in the mountains that seemed a good investment 10 years ago, may have difficulty today in competing with a modern steam-turbine plant in the centre of the power market. However, the initial development period for both tangential water-wheels and Francis turbines, as well as the electrical apparatus, has brought them to a definite and secure commercial basis, and while changes from present models will occur, they will take place more slowly and in a less degree than heretofore.

The very much larger size of units has contributed more than any one thing, probably, to the reduction both in first cost and operating and maintenance charges per unit of power developed. There has been little or no change in the cost of dams and water rights or water conduits—in fact, these items have probably increased slightly, but where a 10,000-hp. plant was about as large as was considered 10 years ago, today 80,000 hp. is nothing uncommon, and at least six times as much power will be devoloped in a power house and on foundations of the same size, and will be handled with no more operators, and transmitted on a line of very little more cost, and marketed for not much more at the terminal. This means that water powers that it would have been impossible profitably to develop then, can be made profitable now and may contribute to the comfort and growth of a community.

Most of the power developments made on the Pacific coast during the past few years have looked far into the future and laid plans for an increase in output commensurate with the expected growth of the markets. The initial installation is but a fraction of the ultimate, and yet it has made necessary the building of roads, the acquisition of water rights, the purchase of water-sheds, the building of duplicate transmission lines, and other heavy expenses—all to secure reliable power, all involving an expense, but returns on which can scarcely be obtained for some years, or until the markets have grown so as to warrant greatly increasing the station capacity.

This is far-sighted and constructive financing, and deserves the encouragement and support of the community, and it is the very antithesis of what I should call destructive financing. The first contributes to the comfort and is entitled to a reasonable profit; the latter bleeds the community for an immediate profit, and is a decided detriment to the comfort and prosperity of the mass of people. In the consideration of corporations it is essential that a sharp line of demarcation be drawn between these two classes. The interests of the first should be studied and no legislation enacted that would retard its valuable constructive influences on the community, whereas the second is entitled to justice only.

Where capital displays confidence, lends itself to the creation of permanent improvement, and provides for the future growth of a market, it thereby most economically furnishes a community with good power or water or any commodity and is decidedly a constructive force for good. Such enterprises must not be confused in any way with the destructive forces which have unfortunately, I believe, been the direct cause of much public sentiment against corporations generally.

Too much cannot be said in favor of good engineering, both as regards the general planning of the power station,

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its placing, water conservation, conduits, transmission lines, and terminal apparatus. The engineering affects to a great degree the amount that must be charged against the property for depreciation. Engineering talent displayed in the design of the apparatus itself, and which carries with it the careful selection of material, securing of good workmanship, and the adaptability of the apparatus to the needs of the service, has the greatest influence on not only the fixed charges, but also on the operating costs and magnitude of returns. On it will depend the continuity of operation, and the number of kilowatts developed with the water available.

Manufacturers of water-wheels are usually depended upon for the design of apparatus, as they are naturally specialists in this line. Their recommendations are entitled to careful consideration—but it is proper to remember that their primary motive is the sale of apparatus, and however well intentioned they may be, judgment warped by considerations other than the customers' interests is not conducive to the greatest success of the development.

The primary consideration of every development is, of course, that of profit, and the first step in obtaining this means the securing of the greatest returns from the power available. Many plants have a limited water supply at some seasons, and then its most efficient use is absolutely necessary to maintain the load, and if a steam sub-station is used on the system, increased efficiency in the water-power plant means the saving of fuel in the steam plant, and this in turn permits more dollars regularly to pass to the credit side of the ledger. By the substitution of apparatus, I recently increased the output of a hydro-electric plant over 50% with a given quantity of water over that obtained with water-wheels which had been used for several years, but had never given good efficiency. This has resulted in a saving of over $2000 each month for each unit because of fuel saved in the company's steam plant alone. The saving effected will much more than pay for the cost of all of the changes in one year's operation.

The cost of the entire hydraulic apparatus is but a small percentage (seldom over 10%) of the cost of the entire development, and frequently much less, and the saving that can be effected in purchasing something cheaper than the best and safest, cannot possibly result in a first cost saving of more than one or two per cent of the total investment. Adoption of the cheaper apparatus is, therefore, certainly not economy in the long run. The hydraulic machinery constitutes the very vitals of the operating system, and the best possible apparatus, even though but slightly superior in efficiency (may be, only at some point on the efficiency curve) or a little more safe, or a little more simple to operate, will in a very short time, fully reimburse an operating company by developing more salable power or avoiding shut-downs (which are expensive luxuries for an operating company), or reducing the oil and the attendance charges.

Anything in the first installation that contributes to the easier collection for power sold, preventing complaints from customers, or which contributes to giving them such good service that they have no cause for complaint, will not only earn many times its cost directly in dollars, but will be the direct cause of creating confidence and good feeling conducive to the interests of both the power company and the consumers.

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San Francisco Sub-Stations of the Pacific Gas & Electric Company

By J. P. BALOUN*

SAN FRANCISCO sub-stations of the Pacific Gas & Electric Co. are fed by duplicate copper transmission lines composed of six separate wires which enter the city at its southern boundary through the sub-station formerly known as 'Martin' station, but now designated by the letter **H**, the practice of naming sub-stations after the men who were the pioneers in the organization of the great system as it exists today having been given up in favor of the simpler and less cumbrous method of using the letters of the alphabet for that purpose.

The primary pressure at Station **H** is 60,000 volts, and, after being reduced to 11,000 volts, the current is transmitted to Station **A** at Twenty-third and Louisiana streets and Station **E** at Vermont and Mariposa streets. Since it is desirable, for practical and commercial reasons, that transmission lines and cables should have distinctive designations, the two overhead cables between Stations **H** and **E** are known as 'powerhouse cables No. 9 and 11.' Taps from these two lines at Twenty-third and Vermont streets are taken at the pole structures and carried overhead to Twenty-third and Louisiana streets and thence underground to the power station known as **A** at Twenty-third and Louisiana streets. There are three other 11,000-volt lines that leave Station **H** overhead to help the United Railroads company in case of emergency, such as failure of its own generating stations. Two of these lines, known as 'California No. 1 and No. 2,' run to the United Railroad company's substation at Geneva and San Jose avenues. The other line, known as 'California No. 4,' is run to the Bryant avenue sub-station of the railroad company by way of Station **E**. Since Station **E** is a switching point as well, it is possible to sectionalize and divert other important cables running from Station **A** to Station **E**, such as No. 5 and 8, as well as No. 9 and 11, for the purpose of helping the railways when the occasion requires. Taking into consideration the fact that each of these copper cables is 0000 size and triplex, and capable of handling electrical energy equal to a maximum amount of 4000 kw. per hour, or over 5300 hp. each, steady performance is assured. The policy of not exceeding the carrying capacity of these cables over the normal rating of 3000 kw. increases their reliability and does away with the element of danger which is ever present when the transmission circuit is overloaded, whether overhead or underground, but more especially in the case of the latter on account of its confined situation, lack of air circulation, and inability to radiate the heat.

The transmission of 11,000 volts on cables No. 9 and 11 from Station **H** to Station **A** is but one phase of the

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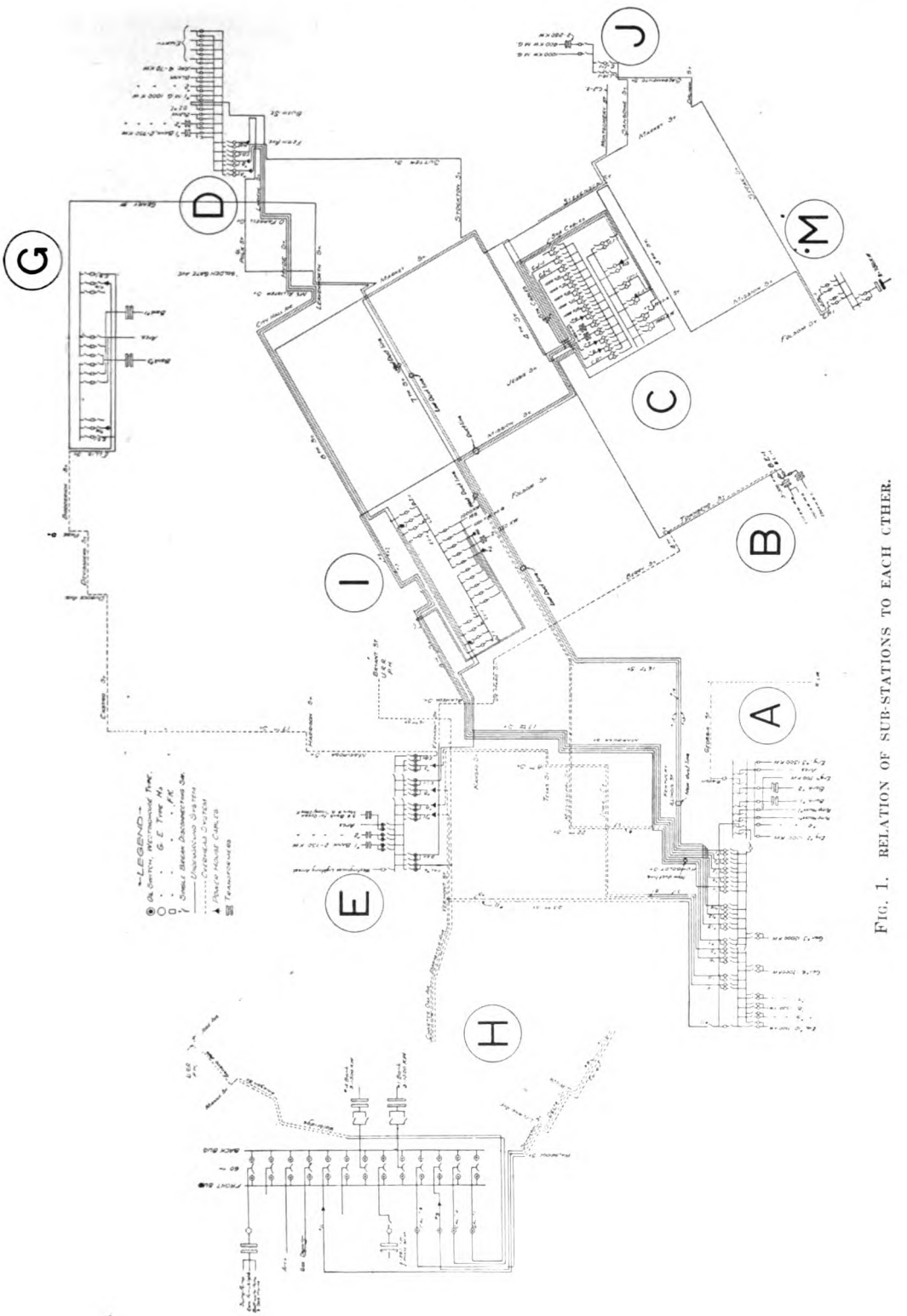

FIG. 1. RELATION OF SUB-STATIONS TO EACH OTHER.

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problem, for since Station **A** includes also a generating plant, it can in turn send out energy at 11,000 volts from its busses through these two cables to fourteen copper cables emanating from Station **A**, ranging in size from No. 2 to 0000 triplex, the majority being 0000 in size, and listed as follows:

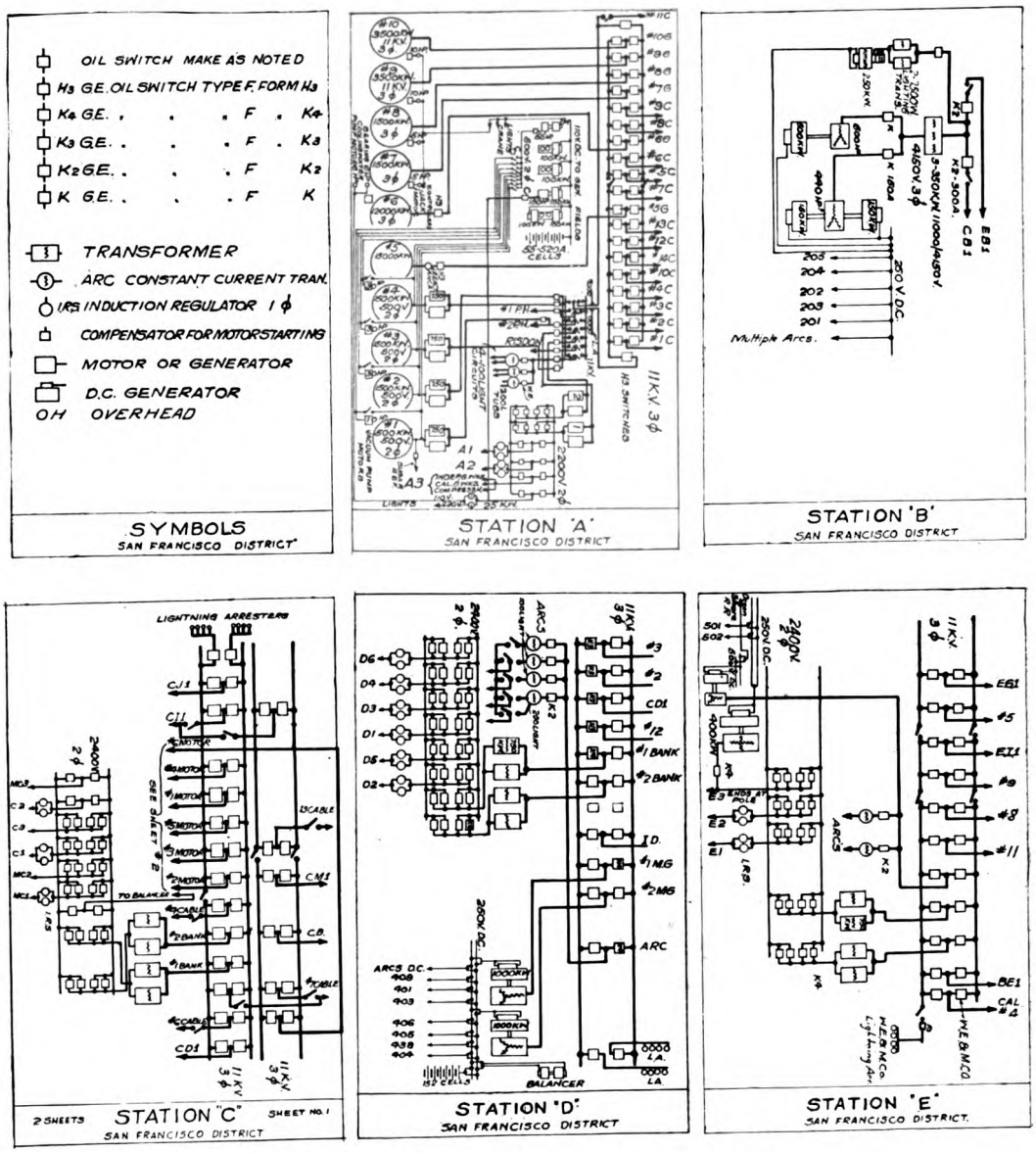

FIG. 2. EQUIPMENT AND FEEDERS OF SUB-STATIONS.

Station **H**, where this may be stepped up to 60,000 volts and thus be synchronized with the remainder of the high-tension transmission system. There are

No. 1 cable runs to Station I, the Eighth street sub-station;

No. 2, 3, and 12 cables run to Station D, the Bush street sub-station;

No. 4, 6, 7, and 13 cables run to Station C, the Jessie street sub-station;

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No. 5, 8, 9, and 11 cables run to Station E, the Vermont street sub-station.

No. 14 cable runs to Station G, the Ellis street sub-station.

Though these fourteen cables into the city from Station **A** control the output from the steam plant to the city, a glance at the accompanying map, Fig. 1, will show how completely all the sta-

tions are inter-connected and provided with switches for an emergency. Thus a cable breakdown does not by any means throw the city into total darkness, for by using certain stations as switching points energy can be brought in by way of a somewhat more circuitous route, thus avoiding the damaged

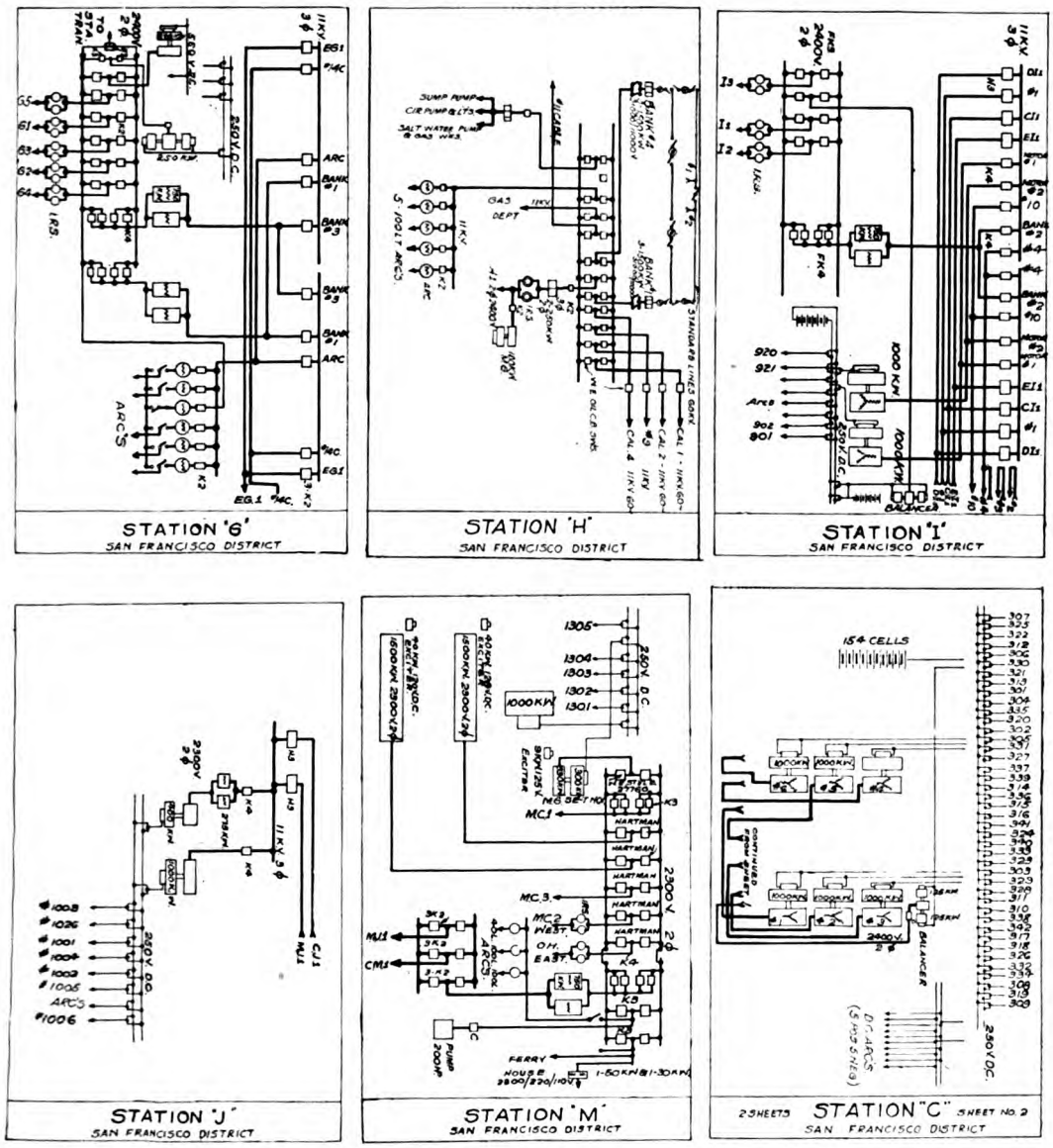

FIG. 3. EQUIPMENT AND FEEDERS OF SUB-STATIONS.

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cable or other temporary street trouble, and the company can still give efficient service from what would appear to be a different source.

As the incoming power-house cables carrying 11,000 volts, together with the distribution lines, are laid underground in all the important down-town sections, the great expense necessitated by employing the best design and construction for the duct system, manholes, and service-holes is apparent. Since the city has no subway for gas, water, and steam mains, and for electric and telephone duct lines, the condition of the almost inconceivable number of pipes, tubes, ducts, and mains running in all directions is most deplorable.

The first of the underground systems in San Francisco were laid by the early gas and water companies, and, as their respective customers were greatly scattered, there was a great temptation to lay mains as short as possible to comply with their wants. As the districts became more densely populated a more systematic arrangement of mains was employed; but as opposition companies came into the field and other enterprises obtained street franchises, the city soon arrived at the condition of affairs that confronts the latest arrival in the field. In most undertakings the pioneer is the sufferer, but in the modern underground pipe, cable, and conduit system, he certainly has the advantage.

The completeness with which the separate sub-stations of this city are equipped and prepared for contingencies, and the varied demands of this large community, is shown by first carefully studying the legend in Fig. 2 and then following the interpretation of those symbols from Stations **A** to **M**, inclusive, as shown in the diagrams in figures 2 and 3.

It will be primarily noted that the double-buss feature is most prominent in nearly all of these stations, so that in case of trouble from one of the copper distributing busses, service can be immediately resumed by switching to the duplicate or spare buss. Another detail that has been adopted and proved valuable, is the sectionalizing of a given buss, the several sections being tied together by means of air and oil switches.

All of the higher-voltage transformers are equipped with fuses for protection in case of excessive voltage due either to accident or the electrical condition known as surging. This condition is comparable to the action of the crest of a wave of water, and gives a higher electrical potential than normal. All fuses of this type are easily renewed with very slight interruption to the service by using a switch on the line provided for this purpose, thus enabling the operator safely to re-fuse the transformer.

All exposed copper or terminals charged with electricity are made as remote from the balance of the apparatus as possible, unavoidable proximity to 'live' switches being made safer by the use of ebony asbestos barriers, which must be removed before easy access is obtained. Ducts have been used in preference to overhead construction. Conduit for instrument wiring is adopted as safer and neater in design than 'open' wiring. Exposed copper busses today are indeed rare compared to early-day practice. Those used are thoroughly protected by insulated tape, so that the 'live' conductor may be handled without danger. It is needless to say, however, that this is not recommended, although as a precautionary measure for the protection of the station operators it has proved valuable.

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Bituminous Macadam Construction*

By A. N. JOHNSON†

OBSERVATION of macadam roads built with a bituminous binder seems to point to the success of this form of construction on many miles of road, and it is with this construction that the present paper will deal without an attempt to discuss further the relative merits of this construction with other classes of pavement. There are many significant features in the construction of bituminous macadam which can be but mentioned here. As with any ordinary macadam construction, it is of prime importance that the roadbed be properly prepared both as to drainage and compactness; yet, fundamental as are these requirements and supposedly well understood as they are, no small number of the failures seen today can be attributed to lack of attention to these important features of the construction. If the roadbed has been properly drained and compacted, there will not be required a greater thickness of completed pavement than seven to eight inches. The material should be put on in two layers, the first layer forming the base on which the wearing layer is to be placed.

The method of placing the base usually does not vary, whatever may be the type of construction used for the top layer. It is essential that this base layer be compact and true to shape, and this cannot be accomplished unless the stone is well spread, thoroughly harrowed and rolled, and then well bonded with stone-dust or gravel in the same manner and with as much thoroughness as though the road were to be left with an ordinary waterbond surface.

The size of the pieces of stone in the different layers is a matter for some consideration. It has been the practice of the Illinois Highway Commission to use stone varying in size from 1 to 2½ in. As practically all of the stone available for road work in Illinois is limestone, there is required a somewhat larger-sized material for surface work than is demanded with a harder variety of stone. Also, it has been found convenient to use but one size of stone in both layers of the road so that the screens at the state crushers are provided with 1-in. holes and 2½-in. holes, and no intermediate size. A dust screen with ⅜-in. holes is used to prepare stone chips from the 1-in. material.

The depth to which the stone is to be spread for the base depends upon the thickness the base is to be after it has been rolled. If the total thickness of the pavement is to be 8 in., the wearing surface is not usually made less than 2½ in. thick, leaving 5½ in. for the thickness of the lower course. If the material for the top course is composed of 2½-in. pieces, it is recommended that

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this layer be made 3 in. thick, leaving 5 in. for the thickness of the base. A layer of stone about 6 in. thick measured loose will roll to 5 in., possibly a little less, depending upon the nature of the material.

After the stone has been spread to the required thickness, which should be done with great care so that there will not be more in one spot than in another. it should also be thoroughly harrowed with a coarse-tooth harrow. The effect of this is to shake the various sized pieces of stone into place, and, as is well known, a box of loose stone can be compacted no better than by shaking them, so, too, the loose stone in the road is compacted by shaking and harrowing, which allows the smaller pieces to take their natural position at the bottom of the layer and the larger near the top. It will be found, moreover, that harrowing the material in this way will permit the roller to compact the material without the creeping that is often observed, and with one-half as much rolling.

The lower course should not be covered with screenings until it has been thoroughly compacted and each piece of rock keyed tightly in place, so that when a wagon-load of screenings is driven upon it, the wheels will disturb the rolled stone scarcely any if at all, and leave no decided rut or track. The screenings should be spread evenly over the whole surface and slightly watered. If the foundation is clay and wet weather has prevailed, the greatest care must be taken in watering the screenings of the first course before the road has tightened, otherwise the surplus water will soften the foundation, which must be dry before further progress can be made. After the screenings have been slightly washed or worked into the stone, more should be spread and again watered, and then rolled to tighten the surface, more water and screenings being added until the surface of the base or lower layer is water-tight. Screenings should not be applied so as to separate the pieces of rock which have been already keyed, but merely to fill the voids in the compacted stone with as little disturbance as possible.

The amount of crown that the finished road is to have will decide the amount of crown that the earth roadbed and the base should have. Space will not be taken here to present the various arguments for a greater or less amount of crown. In general, my observation is that ½ in. per foot is not enough for the average country road with a bituminous macadam top, nor is it practical to exceed ¾ in. per foot. On roads to 16 ft. wide, not less than ¾ in. per foot is advisable. On roads 20 ft. in width or wider, indicating that there is a large amount of traffic spread more or less evenly over the whole road, the crown can be somewhat less than on the narrower roads, but it should never be less than ½ in. On the wider roads, a good practice is to increase the crown somewhat toward the gutter, perhaps starting on ¾ in. and gradually flattening toward the centre, which would be effected by a curved cross-section.

On narrow roads, 12 to 15 ft. in width, it is necessary to give special attention to consolidating at least three or four feet of the earth shoulder on either side of the road, to hold the stone in place. As can readily be appreciated, when the roller is near the centre of the road there is a tendency to push the stone to the side, and if there is nothing to resist this movement, the stone becomes more and more open as the roller proceeds and the pieces of

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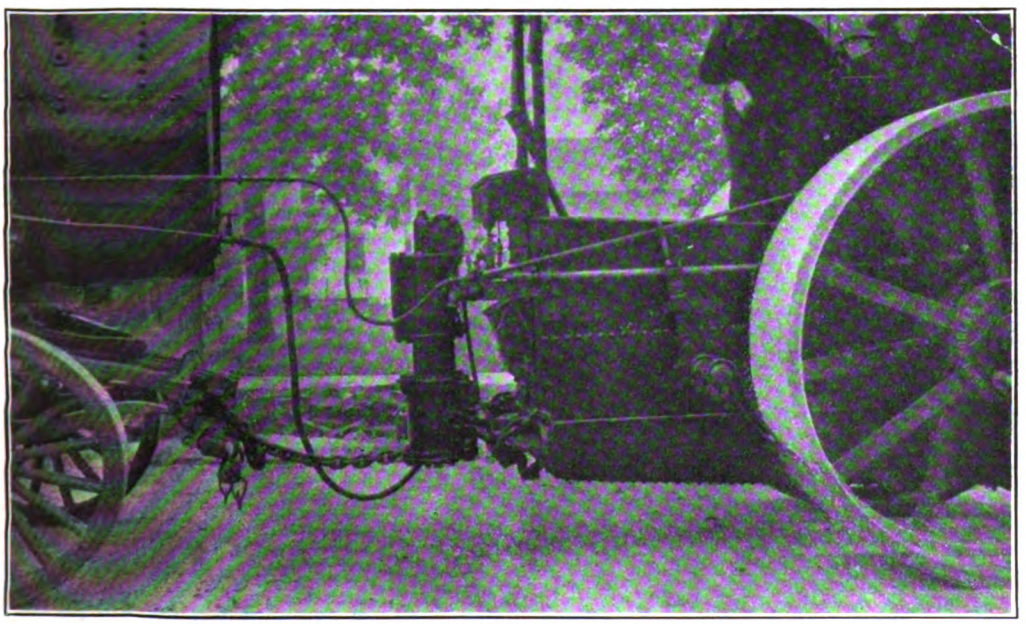
SPREADING FIRST COURSE OF BITUMINOUS MACADAM, MORRISON, ILLINOIS.



DETAIL OF APPARATUS USED BY THE ILLINOIS HIGHWAY COMMISSION FOR SPREADING BITUMENS, SHOWING AIR-PUMP CONNECTED TO THE REAR OF THE ROLLER AND PIPES CONNECTED TO HEATER WAGON.

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rock do not tighten. On wider roads there is not so much difficulty from this cause, as a small amount of rolling toward the edge of the stone at first will make it sufficiently solid to resist any further movement of the stone at the centre, for which reason it is very much easier to get a well shaped, well compacted road that is 18 ft. or wider than one but 12 ft. wide.

There are various methods of construction employed for bituminous macadam surfaces. They are usually divided into two general classes, one where the material is mixed with the binder before being applied to the road, called the 'mixing method'; the other by which the rock is first placed upon the road and the binder poured into it, usually called the 'penetration method.' By far the largest amount of work undertaken by highway engineers on country roads is by the penetration method, for the simple reason that it is much cheaper and more practical under the conditions usually existing in country road work. This method alone will be discussed in detail. Moreover, it is my conviction that with the binders ordinarily employed for this work and for the traffic conditions usually prevailing in the majority of country roads, the best results will be possible with good construction by the penetration method.

As is well known, the stability or strength of a macadam road surface to resist the action of traffic, depends entirely on the mechanical locking together of the pieces of stone making up the road surface, and until this is accomplished the road surface has no cohesion. The more perfect this keying or locking together of the pieces of the stone the more rigidity, therefore the object of any binder, whether of stone-dust or of bituminous character, is to hold the pieces of stone firmly in position after they have become well keyed and locked together. In many pieces of road that have been constructed, and in some forms of construction that have been proposed, this essential principle of the macadam construction seems to have been ignored. This is true, for example, in the type of road employing some form of bituminous binder in which the pieces of stone of the wearing surface do not come in contact at all, but are held apart by the bituminous material which here acts as a matrix, forming in reality a bituminous concrete, similar to ordinary concrete, in which the matrix of cement mortar is replaced with a matrix of bituminous material. If, therefore, the matrix is not in itself sufficiently strong and rigid to withstand the pressure of traffic, such a road is doomed to failure, particularly if submitted to the traffic conditions on most country roads where the traffic tends to keep to a more or less narrow strip of the road, bringing undue pressure thereon. The fact that some of the roads built with a bituminous matrix have proved fairly satisfactory is chiefly because the traffic conditions, under which they are used, so rolls and works the road that one portion receives about as much pressure as another, and if there is a slight tendency to give at one time at any point, subsequent traffic will tend to roll out the unevenness that has been formed. Roads of this character that have come under my observation, although giving fair satisfaction with the conditions under which they are used, would last but a short time under country road traffic. Thus it would appear that, if bituminous macadam is to be successful, it is necessary to follow what has been learned by long experience, and that is, to have the macadam itself

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firmly locked and keyed together and the stability of the road thereby assured before any binder has been applied.

The next step, therefore, after the base course has been prepared, as has already been described, is to spread the stone for the wearing layer. The stone for this layer, if limestone, should be composed of pieces of 2½-in. size and graded from this downward. If a 3-in. layer is to be made when consolidated, which is as thick as this layer need be, the stone should be spread to a thickness of 3½ in. and thoroughly raked or harrowed so as to bring the larger pieces to the surface in order that the latter may be composed in the first instance of as nearly uniform-sized material and to give as great compactness as possible after it is rolled. As soon as spread uniformly and harrowed, the surface is to be rolled until it is thoroughly tightened. It may be found that there will be places where the stones do not lock together firmly; on such places a small amount of stone should be spread, just sufficient to fill the interstices, and then rolled. The effect of the rolling is to force the pieces of stone into these interstices, thus keying the whole surface until tight. It is important that great care be taken in rolling this upper layer, that it be thoroughly tightened. When this has been accomplished, there will still remain interstices of appreciable size which should be filled with stone chips. These chips should be preferably of some harder material than limestone, and it is often possible to secure screened gravel that will prove excellent for this purpose. The size of the chips should vary from 1 in. to ⅜ in., and they should be spread over the surface of the upper course just sufficient to fill the interstices.

A good method to insure this being done is first to shovel the chips on by hand, throwing each shovelful so as to cover as much area as possible; then follow with hand brooms, sweeping ahead the surplus pieces and allowing all the interstices to become thoroughly filled. When this is done, the road is ready for the bituminous binder, as no rolling should be attempted after the chips have been spread and before the binder is applied. If the chips are rolled before the binder is applied, the effect would be merely to allow them to set in between the stones which have already been keyed and tend to loosen the surface rather than to tighten it, so it is important that after the surface has been thoroughly keyed and the chips spread, no rolling be done until after the bituminous binder has been applied.

There are various methods of applying the bituminous binder. One method is to turn the heated binder into cans, thence pouring it on the roads; many roads have been built in this manner. Unless an exceptionally skillful man is employed to do the spreading, places in the road are to be seen, in almost all work of this character, where the binder has been applied thicker in one place than in another. Joints where one sweep of the can was followed by another can also usually be seen. This unevenness is generally much more pronounced after the road has been in service than immediately after the construction, so that evenness in the distribution of the binder is found to be a most important detail. Binders have been spread by machines having a number of nozzles or openings side by side, which are moved over the surface of the road, the binder being thus distributed in a layer a number of feet wide at a time. In some of these machines

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the binder flows from the nozzles merely by its own weight, while with others pressure is applied. Binders have also been applied through a single nozzle at the end of a hose. Experience seems to show the importance of the following conditions being observed. The binder must be spread uniformly, that no more binder be used than is necessary to cover the surfaces of the stone and the chips. To get these results, it is necessary that the binder be put on, as nearly as possible, in the form of a spray, and, owing to the fact that it is practically impossible to get a thoroughly uniform surface before the binder is applied, it may be necessary to apply slightly more binder at some point in the surface than another, so I have found the best results have been obtained by applying the binder through a single nozzle of such a form that the binder is thoroughly atomized and is delivered to the road in the form of a finely divided spray. With this method of application, no difficulty whatever has been found in getting the binder on as uniformly as is required and at the same time having sufficient control to give those spots on the road that may need it the special attention they require.

The device that has been in use on the work of the Illinois Highway Commission consists of a tank-wagon, holding about 500 gallons, supplied with a fire-chamber. The tank, which is cylindrical, is sufficiently strong to withstand a pressure of 60 to 80 pounds if found needful. The tank-wagon is fastened behind a roller or tractor to which is attached a Westinghouse air-pump with a metal hose leading from the air-pump to the distributing tank on which is a gauge so that the pressure may be controlled by the operator of the tractor. Leading from the tank-wagon is a metal hose which ends in a nozzle made of a 2-in. iron pipe with a right-angle bend, in the end of which a plug is screwed, having an opening about ½ inch in size; on the inside is a small cone, so that by screwing the plug more or less tightly, the size of the orifice can be regulated. Leading into the 2-in. pipe forming the nozzle, there is introduced a ½-in. steam-pipe which is connected back to the boiler of the tractor. The steam-pipe extends within the nozzle to just above the orifice. When in operation, the pressure is applied to the wagon, thus forcing out the bituminous binder. The steam is turned into the nozzle as the binder issues. This tends to spray and break the bitumen into very fine particles, producing a sort of mist which can be nicely regulated so that any given amount of material, from a mere wash to any quantity desired, can be applied. It is important that all hose connections for this work be of metallic type, as lighter hose of any other material will soon rot or burn because of the high temperature necessary for most of the bituminous compounds used.

The complete outfit includes an extra heating-tank of the same capacity as the distributing wagon which, as soon as empty, may be readily filled from the auxiliary tank. To do this, the air-pump is reversed, creating a partial vacuum in the distributing wagon, and the binder sucked back through the distributing hose, which is inserted into the auxiliary wagon. With one auxiliary kettle and one distributing wagon, each of 500 gal. capacity, 1500 to 2000 gal. per day can be applied. Additional auxiliary heating kettles would increase the output. Working continuously, a maximum of 500 gal. per hour can be applied. On most jobs, however, where but one roller is available, 1500 to 2000

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gal. per day will be about as much as can be handled efficiently.

The binder, issuing under pressure and carried by the force of the steam, will fill all the interstices and cover the sides of the rock and the chips with a thin layer. Enough of the binder should be applied so as to leave none of the surfaces of the stone that are visible uncovered. Care should also be taken that the binder strikes the surface perpendicularly. If applied in a slanting position, or if the nozzle is moved too rapidly across the road, it will be found that one side of the stones will be covered with the binder, while the other side will have received but little. The amount of binder to be applied should be as little as is necessary to secure a thorough coating for all the exposed surfaces of the stone. This usually requires from three-quarters of a gallon to one gallon per square yard. When this treatment has been applied, the surface should again be covered with the stone chips so as to make practically one layer of the chips evenly distributed over the entire surface of the road. These chips had better be applied as soon as possible after the binder has been spread; if practical, following immediately behind the spreader. They may be spread somewhat in excess and swept ahead with a broom. It is important that the chips be clean and have as little dust adhering to them as possible. One advantage noticed with the steam jet in connection with the operation of this apparatus is that the force of the steam seems to blow the dust from the surface of the stone and thereby insures a cleaner surface for the binder.

After the chips have been spread the second time, more binder is applied in amount sufficient thoroughly to cover all of the chips. This usually requires one-half to three-quarters of a gallon per square yard. Coarse sand, if available, should then be spread upon the road, or finely screened gravel may be used; if neither is available, the stone chips may be substituted. There is no objection to the stone chips if the stone from which the chips are made be of a hard variety of rock, but it is better to use some other kind of chips than from limestone. After the surface has been sanded or chipped just sufficient to prevent the wheels of the roller from sticking, the road should be rolled. The roller should be provided with pipes with small orifices an inch or two apart so as to keep the wheels of the roller wet while rolling. If this is done, there will be no difficulty with the binder sticking to the roller wheels. The rolling should continue until the surface is seen to be well set and compacted. It will then perhaps be found that there are spots needing further treatment to bring them to a uniform appearance with the remainder of the road, in which case, if there be any dust, it should be swept away, a few chips, binder, and sand applied, and the whole rolled to a uniform surface. It is probable that quite as good or better results can be obtained after the road has been sanded and rolled, by throwing it open and letting the traffic develop any places that need further attention.

This form of construction, it will be seen, gives a road which has the strength and rigidity of the ordinary macadam with a water-tight covering of bituminous compound holding the surface of the road intact against the action of motor traffic or dislodgment by the mud that adheres to the wagon wheels. So long as the water-proof covering can be maintained, the road should be in perfect condition, and therefore the only maintenance re-

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quired is that necessary to keep this bituminous covering intact. The chips or sand, whichever may be used, with which the covering is mixed, furnishes the resistance to abrasion. This is greatly helped by the binder, if of proper quality, which will tend to keep the particles covered or imbedded as fast as they may become loosened or broken by the traffic. When in the course of time the surface has become sufficiently worn to expose the stone, making up the wearing course, it can be renewed by thoroughly cleaning the road, putting on a light application of the binder, and renewing the chips or sand. From present observation, there is every indication that such maintenance will be possible at a comparatively small expense and that the bituminous macadam will furnish a character of road surface that is as well adapted as any so far devised, to the ordinary traffic conditions on our main highways at present.

It is evident that, in this form of construction, the character of the bituminous binder plays no small part, and, that to be successful, the binder must have sufficient stability in hot weather so that it will not be easily pressed or displaced and cause an uneven road surface. At the same time it must not become so brittle or hard in winter that it will be broken by the traffic and dislodged by the wind or other forces. To say that such a binder has been found would mean that most of the difficulties in this form of construction had been solved. Some binders have certain qualities that give good results under certain conditions and poor under others. Some binders more nearly meet the requirements than others, but sufficient time has not elapsed since this form of construction was tried to state definitely what binder, in the long run, will prove to be the best. While a conclusion might be drawn today as to which binder is best, further experience may show that some other binder, with somewhat different properties, would have greater durability.

There are two general classes of bituminous binders; those produced from the coal tars and those made from asphaltic oils and natural asphalt, one being a coal tar bitumen and the other asphaltic. Much study has been devoted to both the chemical and physical properties of the various coal tars and coal-tar compounds, and the result of the various compounds in road construction observed, to the end that definite specifications might be drawn to which the compounds should be manufactured. The same is also true of the asphaltic binders. While the variety of compounds of a bituminous nature on the market today is equalled only by the variety of breakfast foods, there is, however, one encouraging fact, and that is that there are few binders that have come under my observation which are absolute failures, while with the majority, good results have been obtained. I have found, however, that it is absolutely essential, if any knowledge whatever is to be had concerning the character of the bitumen used, that it be bought under some definite specification and that it be tested before being applied to the road. Trade names afford no criterion as to the composition and characteristics of a given compound. Doubtless the manufacturers of these compounds can in a measure justify or excuse the variability of their products by the fact that they are called upon to fulfill so many different specifications that they might well argue if engineers and road builders are so divided in their opinion as to what is desired and wanted, surely lit-

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tle or no harm could result by furnishing binders of various characteristics. They are perhaps waiting before standardizing their output, until the chemists and engineers are more nearly in accord as to what should be used. However, the latitude that manufacturers allow themselves in many of these cases is rather greater than most engineers and chemists, who have given the subject careful study, desire, and therefore the recommendation is here made that the binders be bought under specification and be tested to see that the qualities desired have been secured. There is little or no difficulty in manufacturing binders to meet any reasonable specification.

For coal tars, the following specification has been used by the Illinois Highway Commission:†

Specific gravity at 25°C. shall not be over 1.24.

Free carbon shall not be over 20% by weight.

The consistence as determined by the Howard & Morse float apparatus at 50°C. should be between 2 and 3 minutes.

The fractional distillation shall result as follows:

To 110°C. not to exceed 2% with no ammoniacal water.

From 110 to 170°C. not to exceed 5% distillate, of which not more than one-fourth shall be naphthalene when cold.

From 170 to 270°C. not to exceed 30% or be less than 20%; of which not over one-third shall be solids when cold.

Over 270°C. not less than 63% by volume of pitch residue to be obtained, which shall not be granular in appearance.

When a cylindrical prism of tar 1 centimetre in diameter is maintained at a temperature of 0°C., it shall bend into a semicircle of 3 centimetres in diameter without checking.

For asphalt binders, the following specifications are now in use:

The asphalt shall have a specific gravity not less than 0.96 at 25°C.

The asphalt shall be soluble in cold carbon bisulphide to the extent of at least 95% by weight, but in no case shall the asphalt contain more than 0.5% by weight of organic matter insoluble in cold carbon bisulphide.

Of the total bitumen not less than 20 or more than 25% shall be insoluble in 86°B. naphtha.

When 20 grams (in a tin dish 1½ inches in diameter, with vertical sides) is maintained at a temperature of 170°C. for 5 hours in a New York testing laboratory oven, the evaporation loss shall not exceed 2%, and the penetration shall not have been decreased more than 25 per cent.

The fixed carbon shall not exceed 12% by weight.

The penetration as determined with the Dow machine, using a No. 2 needle, 100 gm. weight, 5 sec. time and a temperature of 25°C., shall not be less than 5.0 or more than 10.0 millimetres.

The asphalt shall not contain to exceed 2% by weight of paraffine.

The question as to whether tar or asphalt compounds give better results is one on which I cannot at present express an opinion, merely because experience so far had with these different compounds does not warrant definite conclusions. Both good results and poor results have been obtained with each of these bituminous materials. Some engineers are of the opinion that under certain traffic conditions, better results may be had with one class of material than another. For instance, with a preponderance of motor traffic, the opinion seems to be in favor of asphaltic compounds, and with a preponderance of steel-tire traffic, that the tar compounds prove the better. However, these conclusions, as far as I have had opportunity to test them, seem to have been drawn chiefly from merely surface treatments of old roads. Nothing that I have observed seems to indicate that a similar distinction can be made from roads constructed as has been here described.

The specifications for bituminous material, for the form of construction as herein outlined, are presented, not so much as affording absolute criteria, but

†For details as to methods of analysis of bituminous compounds, the reader is referred to Bulletin No. 38 of the U. S. Office of Public Roads.

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as a suggestion and guide to those who desire to purchase these materials and use them and who may not have given the subject extended inquiry. It is entirely possible, in fact quite probable, that these specifications will be changed and other requirements found necessary as more experience is gained from the work already done. In general, it has been the plan in the past year or two in the use of these binders, on work under the supervision of the Illinois Highway Commission, to use on each stretch of road at least two binders and so to distribute them on different jobs that each will be placed in juxtaposition with some other. Thus, with a chance to compare each binder with a large number of other binders, and by observation of each binder under various conditions, it is hoped that reasonably exact conclusions as to their fitness for use in this form of construction may be formed.

THE FINISHED ROAD, OBLONG, ILLINIOS.

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Handling of Freight at Pacific Coast Harbors

By G. W. DICKIE*

THE opening of the Panama canal will change the character of the seaports on the west coast of the United States, as a marked increase in water-borne freight from Europe and the eastern coast will undoubtedly result. How to handle this freight will be the problem for each port, and the harbor that first offers the best facilities, with the natural advantages that must accompany them, is going to reap the greatest benefit from the new conditions that will prevail in all matters of transportation. These problems of freight handling are now being discussed at all the principal ports on the west coast. Seattle and Tacoma on the north are each considering important improvements to their dock facilities; Portland, the port of Oregon, is also considering what she can do to attract some of the new ocean trade; the ports of Los Angeles and San Diego on the south have each schemes on foot looking to modern facilities for shipping at their harbors; while the great central port of San Francisco, embracing several harbors on the bay, has extended plans for the future. In view of this general activity in regard to the necessity for better dock facilities, it will be instructive to consider the line along which these facilities should be developed.

Tidal conditions which prevail at practically all the Pacific Coast harbors are such that properly constructed wharves of enduring materials will give as satisfactory results as the more expensive wet docks that are such a prominent feature in the great harbors of Europe, where the large rise and fall in tide makes such docks a necessity. The size of wharf and the character of its equipment are of great importance. These questions should be determined by the depth of water available and the commercial importance of the port itself. These features will determine the size of vessel and the amount of business that will have to be provided.

Up to the present time there are no public facilities at any of the Pacific Coast ports for handling cargo. The reason for this may be found in the fact that the business at these ports has grown gradually, that the foreign trade is largely in the hands of foreign shipping houses, and that the coasting trade, which is extensive, has been to a large extent between ports where at least one of the terminals is owned by private interests; hence the ships in the coasting trade have to carry their own facilities for handling freight. This applies also to ships in the inter-coast trade such as those of the American-Hawaiian Steamship Co., which are fitted with splendid facilities for handling freight. The ships in the oil-carrying trade, which has grown to such large proportions, have also of necessity

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their own means of handling cargo.

Another important interest is the lumber trade, and the ships in this business are all well equipped with the most efficient appliances for handling their special freight. In fact, it may be said that the lumber-carrying steamers on the Pacific coast are able to handle this special character of freight in quicker time and at less cost than any other lumber-carrying ships in the world. This is due to their superior means of handling coupled with the type of ship, which usually carries about 60% of its load on deck.

The passenger and freight steamers operating on the Pacific coast are also about as well equipped for handling cargo as it is possible for a passenger ship to be. In their case a good deal of the handling is done through side ports, where trucking, either in or out through the ports, goes on at the same time as hoisting through the hatches. It does not appear that much change or improvement can be made in these methods of handling freight except by some radical change in the design of the ships or by introducing some method of handling between wharf and ship that will be erected on the wharf.

Wherever homogeneous cargo forms the great bulk of the water-carried freight, as on the Great Lakes, a system of handling, of marvelous efficiency, by devices erected entirely on the wharf or dock has been developed; the ship being specially designed to suit the handling machinery at the terminal wharves. In all the great new harbors and docks that have in recent years been constructed at the ports of Europe and Great Britain, the planning of the docks and the warehouses connected with them has always had a close relationship with the means of handling cargo, and one has only to visit some of these great ports and compare the facilities at the older docks with those at the newer to see how steady and rapid has been the development in the type of machinery for handling the goods carried by water.

This development of handling machinery on land has resulted in the ships now built for carrying general cargo being designed with the understanding that the cargo-handling machinery will be on the dock and not on the ship. It is this expectation of the ship-owner that must be reckoned with in designing the facilities to be provided at the ports on the Pacific coast. Very few vessels are now, or are likely to be, fitted with side ports, as the classification societies do not favor such ports and require much local compensation work to make up for the material cut from such openings. Provision should therefore be made at all new wharves for the cargo, both incoming and outgoing, being handled vertically, which would naturally lead to a better arrangement of hatches on the part of the naval architect. If longitudinal framing should be adopted for the decks instead of cross-beams, electric trolleys could be worked between the longitudinals for horizontal transportation between decks; the hardest problem connected with heterogeneous freight.

It will be useful to consider the wharf and its facilities for handling heterogeneous freight from numerous consignors to numerous consignees, delivered to or by teams or railroad cars and from ships that receive and land passengers as well as freight; and one port, San Francisco, may serve as an example—although nothing will be proposed that is not equally adapted to any port on the Pacific coast of the United States. In regard to the wharf itself, the construction should be such

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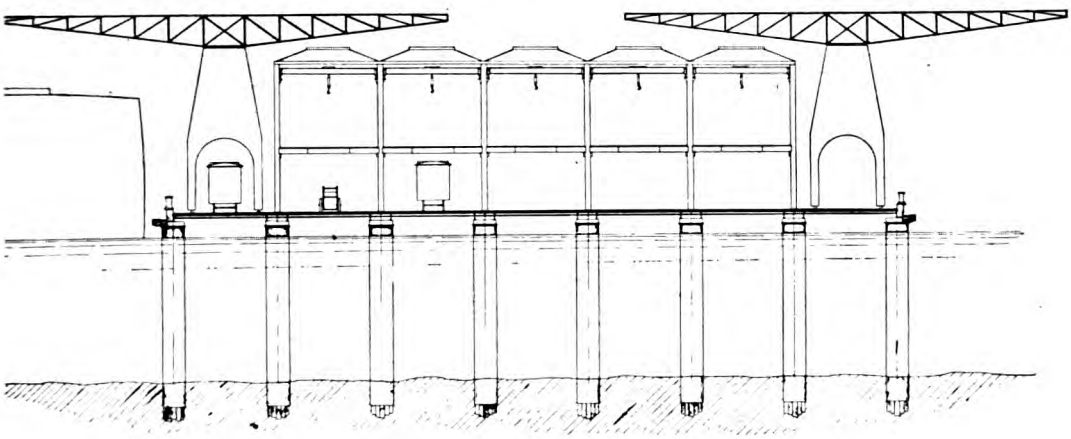
as to insure as long life to the structure as possible. The concrete columns supported on piles do not appear to have as yet established their ability to outlast the life of the bonds that represent the cost of construction. In 1884, I designed and constructed the hydraulic dry-dock at the Union Iron Works, San Francisco, the superstructure of which was destroyed in 1906. The supporting piers for the side girders of this dock consisted of clusters of piles driven inside iron cylinders which extended several feet below the bottom line of the dock, the piles being faced off in line with the top of the cylinders and surmounted by a cast-iron cap, on which rested the girders of the dock. As these piers, so far as I know, are still standing, it would be a wise thing for the Harbor Board of San Francisco to carefully examine them and determine if the piles thus protected are still in sound condition after 28 years, because such piers possess the elasticity that is absolutely necessary in a wharf, even with the most elaborate guard of spring fender piles. The cylinders under the wharf should be arranged to be directly under the columns supporting the upper floor of the shed on the wharf. The floor or deck of the wharf should be of asphaltum and each bay should be crowned for drainage. The width of wharf should be 175 ft. inside the coping, and the length should be about 800 ft.; this would allow of loading and discharging barges and river and bay craft at the end of the dock and leave sufficient clear length of berth on each side for the larger class of steamships. There would be 8 lines of piers under the wharf spaced 25 ft. centre to centre transversely, and 32 lines of piers longitudinally, making in all 256 piers, and each pier should contain 13 piles; this would require the cylinders to be 5 feet 6 inches in diameter.



PROPOSED FREIGHT-HANDLING DOCK.

The arrangement would work out somewhat like the outline cross-section shown. The shed would be 125 ft. wide in 5 bays, each 25 ft. from centre to centre of columns. There would be no freight landed or assorted on the lower floor or wharf inside the shed. Each of the outside bays would be for teams. As they are relieved of their loads or receive loads through the hatches in the floors above, they proceed as they are going to the outer end of the dock,

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where they turn toward the centre of the shed and return through the centre bay. Railroad cars could be shunted into the shed by the second bay on each side and pulled out when loaded or emptied as the case may be. The cars also receive their loads or deliver them through the hatches in the floor above. In this arrangement it is taken for granted that all box-cars will be fitted with roof hatches by the time such wharf facilities are ready for them.

In order to allow teams entering the wharf with loads to be delivered at points beyond where other teams are unloading and prevent waiting, it may be better to have the hatches through the floor above at alternate sides instead of in the centre line; this would enable a team coming in to pass another team unloading. There should also be platform elevators to receive box goods that can be handled quicker by hand than by crane. These elevators could be placed between the pillars and would serve the railroad cars as well as teams. It would also add to the efficiency of the equipment of the wharf if there were turn-tables on the outer end so that the tower cranes could be moved from side to side of the wharf, as more might be needed on one side than on the other. The tower cranes should be lightly roofed and the roof should be extended to cover the hatches in the roof of the sheds; thus enabling freight to be handled without danger of damage in wet weather.

The second floor of the shed is designed to be entirely devoted to the handling and sorting of freight, and its delivery either to cars or teams below, or the ship-loading cranes above. There will be 10 traveling cranes, 2 in each bay, that will have command of the whole floor. These would be of about four tons capacity and of high speed.

As, on the steamships which may berth at such a wharf, the distance may be from 30 to 40 ft. from the water-level to the hatches from which cargo is to be discharged, the loading and unloading facilities must be of such a character as will meet such conditions. I would therefore propose that tower cranes be furnished, 6 on each side of such a wharf. These may be moved on a track of 16-ft. gauge, and should have a double cantilever arm, extending 53 ft. beyond the centre of the tower in each direction. Two hoisting trolleys should run in the arm, so as to do rapid work, one delivering its load while the other is securing and hoisting another. The roof of the shed should have hatches along the centre line, so that the cranes might be in any position and still reach a hatch on the roof. As these cranes also bridge the track on the outside of the shed, they can deliver into cars or teams direct. When not in use they should be turned in line with the shed, so that the arm would be out of the way of ships docking.

Such a dock as is here described would not be a cheap structure. An approximate estimate of the cost of this wharf with all its appliances, and provided that electric power was supplied by one of the power companies, indicates that the cost complete with equipment as shown would be about $675,000, but for the business of the port it would be worth several of the wharves now in use, which are without any means of handling freight.

This is not a scheme for any kind of homogeneous freight, but is an effort to provide the means of handling at the least cost the usual run of heterogeneous freight, which is the kind of freight that is to form the bulk of the increase that the Panama canal will furnish to the Pacific ports.

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The San Juan Oilfield

By W. T. MacDONALD*

MEXICAN HAT is a well known landmark in southeastern Utah. It is in the very deeply eroded region in which is situated the San Juan oilfield, which in the past two years has attracted attention to the latent possibilities of wealth in the great and little visited area. The oilfield itself is traversed by the San Juan river, and the present centre of activity is near the recently established townsite of Goodridge, some thirty miles by wagon-road, west of the little town of Bluff. The approximate latitude of Goodridge is 37.2° north, and the longitude about 110° west. The probable size of the field has been variously estimated—one engineer having reported the promising area to be as large as fifty by ninety miles in extent. While this may be true, the actual prospecting by the drill has only embraced a territory of perhaps 10 by 15 miles. Practically all the effective prospecting has been done on the northern side of the San Juan river. All that part of the state of Utah lying south of this river and east of the 110th meridian is included within the Navajo Indian Reservation, and, consequently, none of such territory is to be counted upon as possible and obtainable oil land. The land lying south of the river, and extending westward from the same meridian for a considerable distance, is within the limits of another Indian reservation—but can be prospected for oil and locations can be made by permission of the Secretary of the Interior. The general position of the field is shown in the accompanying sketch-map, which shows the situation with reference to the main railway line.

The field may be reached by three different routes—each of them unsatisfactory, tedious, and consuming of time and patience. From Thompson's Springs (sometimes called Thompson) on the north—a Utah station on the main line of the Denver & Rio Grande—a stage is run three times a week, by way of Moab and Monticello to Bluff. The distance to Bluff is stated to be 160 miles, and the journey requires three days. No regular stage is run from Bluff to the oilfields. Most of another day is consumed by this final portion of the journey. From Dolores, on the east—a Colorado station on the narrow-gauge line of the Rio Grande railroad—a stage is run every day excepting Sunday, by way of Cortez and McElmo Canyon to Bluff. The distance to Bluff is given as 85 miles, and the trip consumes three days. From Gallup, on the south—a New Mexico station on the main line of the Santa Fe railroad—a wagon-road has been built into the field. The length of this road was variously stated to be from 160 to 190 miles.

The town of Bluff has a permanent population of perhaps 150 people, and

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lies on the northern bank of the San Juan river, at a place where the low-rimmed canyon widens out to form a natural townsite. Agriculture, sheep and cattle raising have served to place most of the Bluff inhabitants in moderately good financial circumstances. There are two stores in Bluff which carry a fair stock of merchandise, and from which much of the provisions for the field are drawn. Livery rigs to and through the oilfields can also be obtained there.

As already mentioned, the centre of the present activity in the fields may be taken as being in the vicinity of the recently established townsite of Goodridge, and about thirty miles westward, and down the San Juan river from Bluff. A general merchandise store has been established, the stock of supplies having been hauled in over the new road from Gallup, New Mexico.

No attempt will be made here to discuss the detailed geology of the region. In the immediate vicinity of Bluff, there is exposed thick, nearly horizontal, beds of reddish sandstone which may also be noted much of the way along the stage journey from Cortez. Proceeding from Bluff, on the road into the fields, the same formation continues without an apparent break of any kind, for a distance of perhaps six or seven miles, to Comb ridge. Here there has been a tremendous disturbance and upheaval of the earth's crust, resulting in the formation of the ridge, which is several hundred feet in height and extends for many miles in a northerly and southerly direction. The strata are steeply tilted, crumpled, and broken, and extensive faulting has taken place along the northerly and southerly axis of the ridge. The vertical displacement of the strata amounts to several hundred—perhaps a thousand—feet. It brings to the surface formations which are elsewhere deeply buried. Limestones appear in great profusion. The lowest formation made visible probably belongs to the Carboniferous.

Passing from the ridge down the river, the traveler soon enters the eastern limits of what is at present claimed

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to be the probable oil-producing territory. The district included within the limits of the oilfield may be broadly described as having been once an almost horizontal plateau, since bent into a series of enormous anticlines. These trend generally north-south, and for the most part are broad and slope gently; perhaps 80 to 100 feet per mile. In places the beds are steeper. In no place that I observed was there any evidence of a sufficient abrupt vertical displacement to be the result of faulting. Most of the drilling that has been done thus far has been confined to the eastern slope of the second anticline, proceeding westward from Comb ridge. Some few wells have been drilled, or are now being drilled, in the syncline at the eastern limit of this anticline.

The first anticline seen, after leaving Comb ridge, approaches to a quaquaversal dome in shape. An examination shows the strata on every side to be tilted upward and to extend smoothly over the top of the dome, excepting where cut through by erosion. This dome probably measures five by ten miles in extent, and is cut squarely through some distance north of its centre, by the canyon of the San Juan river.

Aside from the anticlinal folding here noted, the horizontal strata of the entire district are practically undisturbed, and the region is at a considerable distance from any prominent range of mountains.

Under these conditions, a possible explanation of the origin of this anticlinal structure, would be the presence of underlying laccoliths of igneous rock, which surface erosion has as yet not brought to light. This theory receives support from the fact that on the south side of the river, a little to the west of Goodridge, there is a bold outcrop of a dark greenish igneous rock, known locally as the 'Alhambra.' I visited this locality, but did not have time to actually reach the Alhambra itself, and could detect no signs of any serious or extensive disturbance resulting from its presence. It may have been an igneous intrusion which cut its way up through the overlying and semi-plastic sedimentary deposits—or it may be the top of some old, submerged, igneous peak, around which the ancient inland ocean deposited its sediments undisturbed.

On the north side of the river, however, I noted and carefully examined another igneous dike, which I am inclined to think may have a certain influence on the productiveness of a portion of the field. This dike appears to be a hornblende schist, and has an average width of from four to six feet. It strikes nearly due north and can readily be traced for some two or three miles. It seems to be almost vertical and outcrops along the eastern slope of the before-mentioned second anticline, perhaps two miles from the bottom of the synclinal valley. I followed this dike down to within about two and one-half miles of the river. No particular significance appears to have been attached to the presence of this dike by those operating in the field, but it is worthy of note that up to the present time none of the wells (of which there are several) which have been drilled east of this dike, have yielded as well as have several of the wells drilled west of it, or its probable exclusion to the river. All of the wells east of this dike, and situated in the synclinal basin, have, however, shown the presence of a considerable amount of water.

The entire district now embraced within the limits of the fields was originally covered by horizontal water deposited strata, aggregating a tremen-

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dous thickness. In most places, however, surface erosion has removed the overlying formations to a depth of several hundred feet—and possibly for thousands of feet. As a result of the erosion and differential weathering, various reddish colored, isolated, and picturesque bluffs, buttes, and monuments have been left dotted over the field, rising in many cases to hundreds of feet above the surrounding territory. The San Juan river has cut its winding tortuous way through the heart of this district in a northwesterly direction. At Goodridge, the canyon is comparatively shallow, but it gains depth proceeding down the river, until in some places in the western portion of the field the river bed lies 1400 to 1500 ft. below the top of the encasing walls.

Seven so-called 'sands,' which may prove to be oil-bearing, are exposed in this canyon; all of these being, however, of the consistence of a firm sandstone. The uppermost, known locally as the 'Goodridge' sand, is partly cut by the river at the townsite of Goodridge, and here I saw oil seeping from it into the river. The paraffine contained in the oil seems to be congealed and deposited by the water at the line of contact of the sand with the river, and in places gritty masses of a blackish color and a putty-like consistence can be detected. Porosity tests made upon samples of this Goodrige oil sand have shown them capable of absorbing from 10 to 20% of their own volume of oil. This Goodridge sand, where cut by the river, shows a total thickness of about 50 ft., but probably not more than 20 to 30 ft. of this would be productive of oil.

Oil seeps are also reported from at least four other sands, the seeps from the sands, locally known as the 'Mendenhall' and the 'Honaker,' being especially pronounced. The Mendenhall sand, where visible, lies about 700 ft. below the Goodridge, while the Honaker is found about 500 ft. still lower. On the Honaker trail into the canyon, at one place about 1000 ft. below the Goodridge sand, I noted a 4 to 6 ft. stratum of black shale which when freshly broken had a noticeable odor of oil, and where directly exposed to the atmosphere and sun, had a pronounced tendency to split into layers, scarcely thicker than a piece of heavy writing paper. The combined thickness of the various sands exposed in this canyon, which may prove to be oil-bearing, amounts to 200 or more feet. It is but reasonable to assume the possibility of other similar sands existing below the present river level.

The London & San Juan Oil Co., when visited, was operating a No. 28 Star drill on what is known as the 'High-Grade' group of claims, using wood for fuel. The first well was drilled 85 ft. deep, striking Goodridge sand at about 40 ft. This sand showed sufficient oil to be considered a legal discovery. The second well was down at the time 185 ft. The Goodridge sand had been found at about 50 ft. giving the same showing of oil as in the first well. The intention was to continue sinking this well to perhaps 250 ft. with the hope of getting sufficient oil to use for fuel under the boiler. The well is about one mile southeast of Bell Butte. After I left the field a splendid showing of oil was found in this well. At a depth of about 450 ft., the drill penetrated an oil sand, which promised to become a good producer. Several barrels of oil were removed by the bailer, and the oil appeared to be of the same excellent quality noted in the other producing wells of the district.

This well is approximately five miles from the Arcola well No. 2, being up

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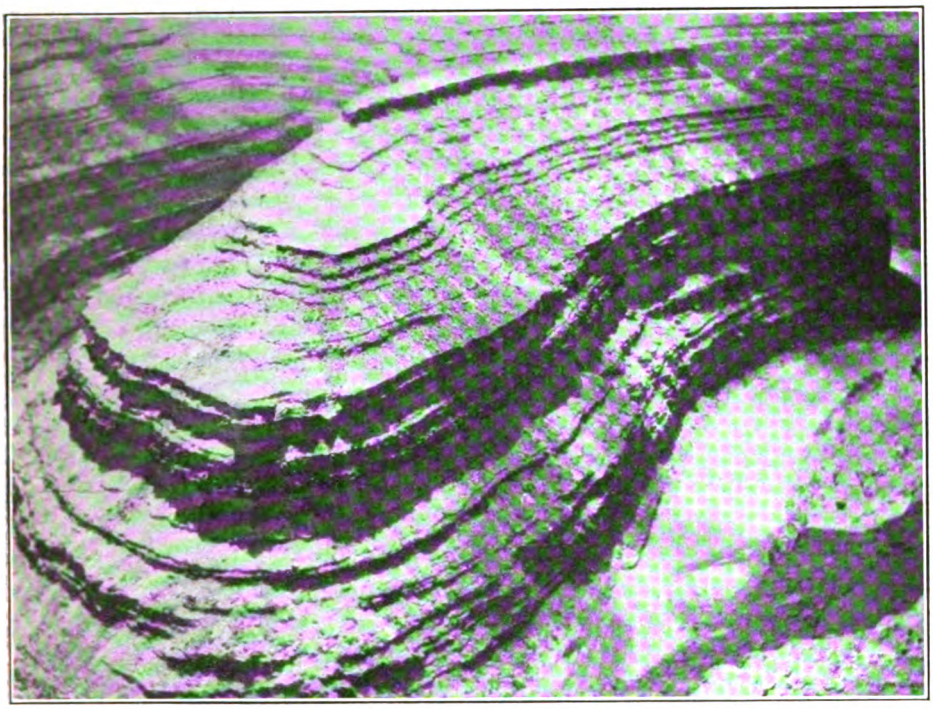

CANYON OF THE SAN JUAN RIVER.

GOODRIDGE WELL NO. 1, SUPPLYING OIL.

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the anticlinal slope from the latter. The oil sand is probably the same sand which the Arcola well No. 2 cut at a depth of about 400 ft., and which sand, at that place, also gave an excellent showing. The sand which the Arcola company is now pumping from the No. 2 well, lies about 200 ft. still deeper. The finding of oil in this well is a matter of great importance, as it means that what may be termed the 'proved' area has been greatly extended. It is but reasonable to suppose that if this sand is productive at this point, the lower sands will also prove to be producers.

The San Francisco & San Juan Oil Co. has already drilled several shallow wells in different parts of the district. It was operating a No. 26 Star drill on the Timbucktoo claim. The rig was about 2½ miles southeast of that of the London & San Juan Oil Co. The well was down 142 ft. at the time of my visit. A slight stain of oil appeared on bailing water. A good supply of water suitable for boiler purposes was found at a depth of 91 ft. Oil, supplied by one of the Arcola company's wells, was used under the boiler. The price paid for this oil was $2.50 per barrel at the well side. I was told that from three to four barrels of this oil is required daily to operate the rig.

The Oil Company of San Juan has already drilled a number of wells, mostly shallow, in different parts of the field. It was operating a No. 21 Star drill on what is known as the Burlap claim, situated about a mile to the west of the 'Mexican Hat,' when visited. The well was about 220 ft. deep. Oil from the Goodridge well No. 1, belonging to the same company, was used for fuel. This well is situated about two miles southwest of the Burlap well, and was drilled to a depth of 220 ft., early in the year 1908. It penetrated through the Goodridge sand. A splendid showing of oil was found, and although the well has never been shot, nor even properly cased, it is furnishing from three to five barrels of oil per day. The well has just recently been equipped with a Fairbanks-Morse gasoline pumping engine. The crude oil runs this engine, with satisfactory results. It is necessary, when starting the engine, to use pure gasoline until the cylinder becomes heated, after which the crude oil is substituted. This well makes considerable salt water, which should, by all means, be properly cased off, and in addition the sand should be shot, before the best results can hope to be obtained. No figures of the oil which this well has produced to date have been kept, although I was informed that when the oil sand was first drilled into, the oil rose in the well and flowed gently over the top of the casing for several days.

The Arcola company, a year or two ago, drilled one well in the Mexican Hat basin to a depth of 420 ft. A good showing of oil was obtained in the well, and perhaps a barrel was recovered by bailing. The well was drilled for discovery work only. The second well was drilled at a point about two miles north of the townsite of Goodridge, and perhaps one and one-quarter miles nearly due west of the Mexican Hat. It was drilled in a gulch which cut through the top formation, and consequently started at a geological depth of about 100 ft. below the Goodridge sand. At approximately 200 ft. in depth salt water was found; at about 400 ft. an oil sand was penetrated from which perhaps two or three barrels of oil per day was bailed for several days. This sand was 18 to 20 ft. thick. The well was continued to a depth of approximately

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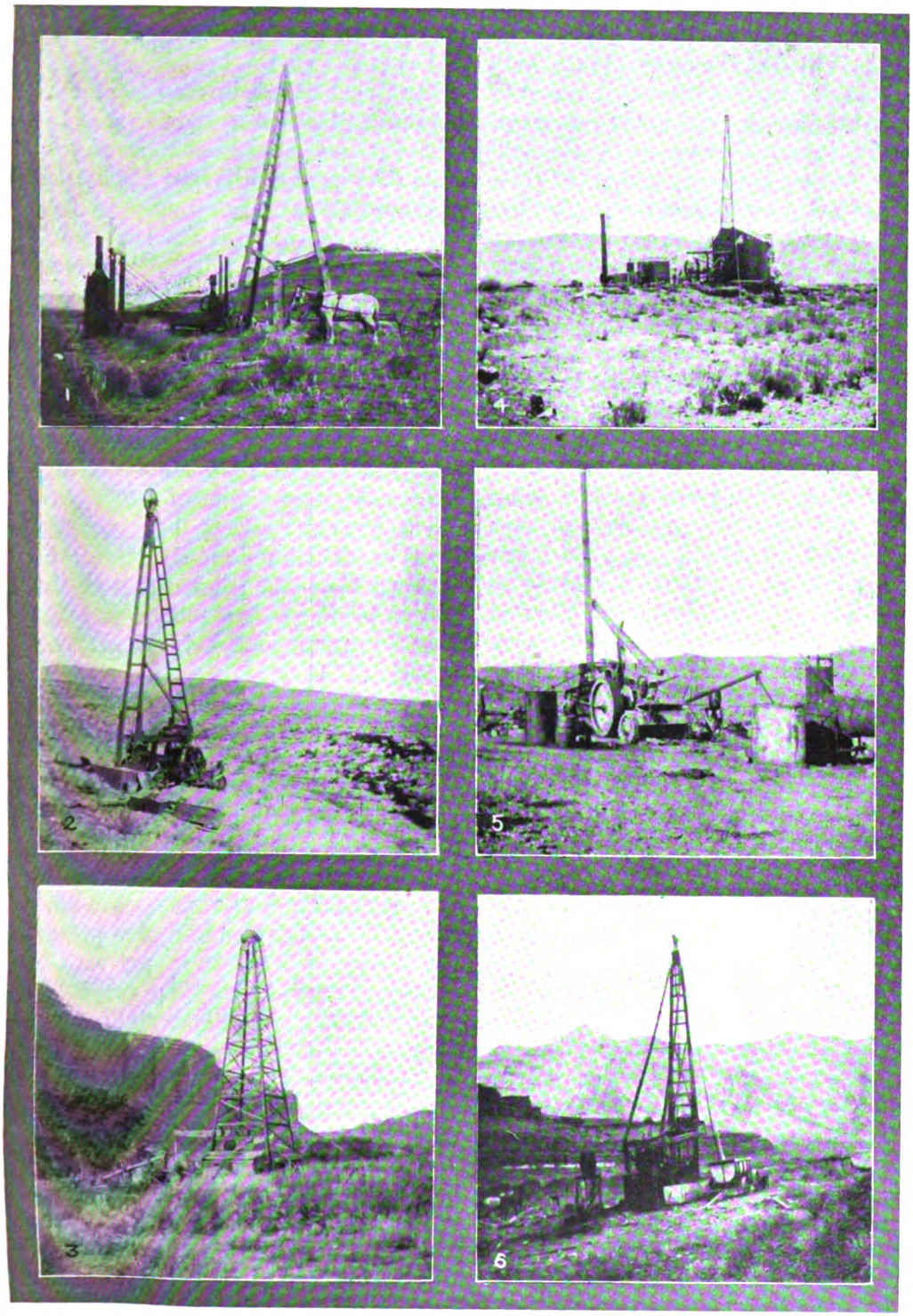

1. ASHURST CAMP; AMERICAN ROTARY DRILL. 2. REDWOOD OIL CO.; DEMPSTER DRILL RIG. 3. GALLOWAY BROS.; STANDARD DRILL RIG. 4. CONNECTICUT OIL CO.; NO. 5 COLUMBIA DRILL RIG. 5. SAN FRANCISCO & SAN JUAN OIL CO.; NO. 26 STAR DRILLING RIG. 6. MONUMENTAL OIL CO.; NO. 5 KEYSTONE DRILL RIG.

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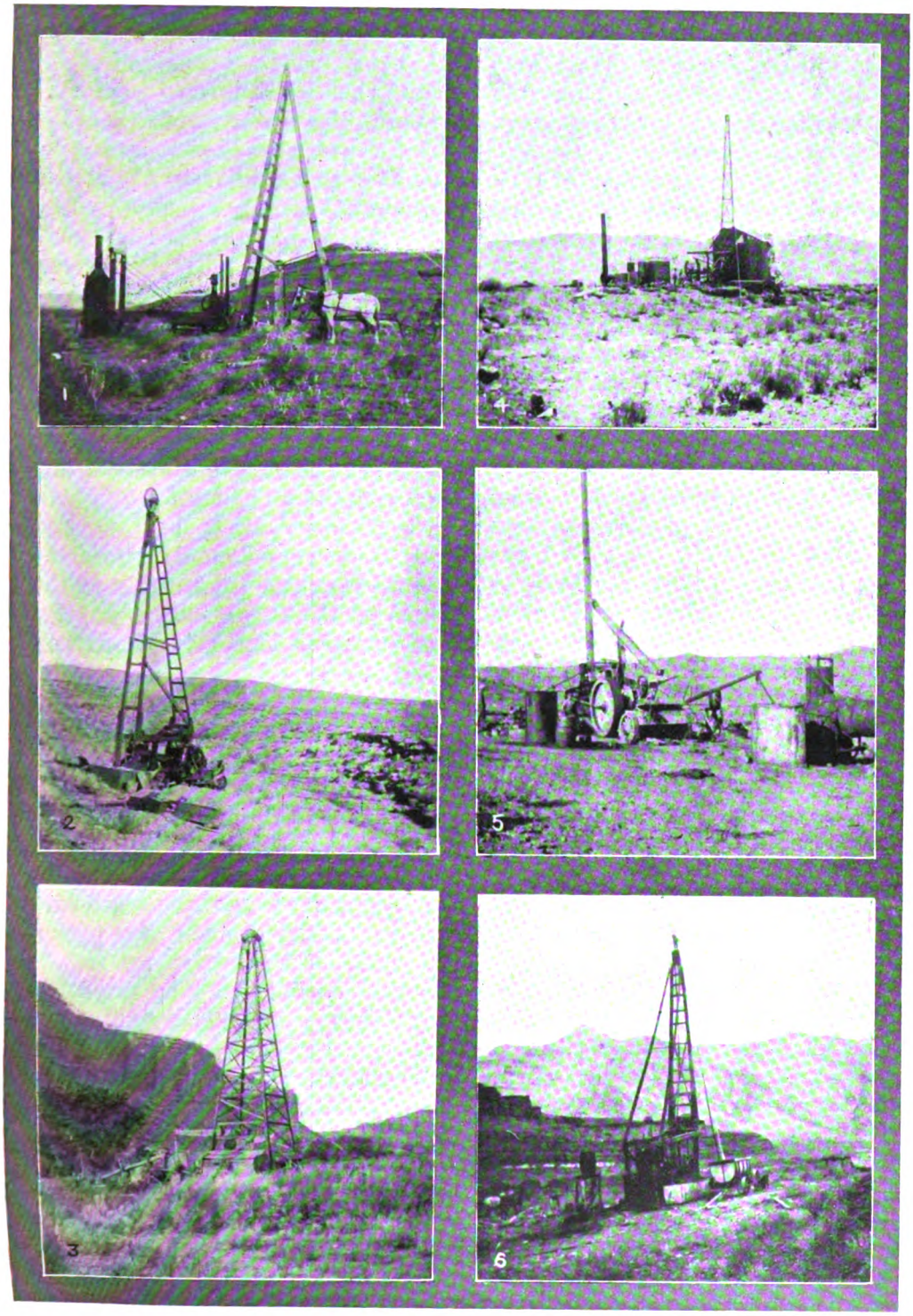

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610 ft.; the drill passing through 17 ft. of oil sand at the bottom of the well, and into 18 in. of a firm rock, stated to be much like jasper. This lowest oil sand is supposed to be the Mendenhall. The well was shot early in June of 1911, using 50 lb. of 60% dynamite. The bottom of the casing was seriously damaged by this shooting, and for a time the well was practically closed. The operators finally succeeded in getting it opened, and since that time it has been the best well thus far drilled in the field. It is equipped with a Fairbanks-Morse pumping engine, and it is now regularly supplying four and sometimes five drilling rigs with fuel oil. Since being shot, this well has produced perhaps 500 to 600 bbl. of oil, and when I was in the field was regularly producing 10 to 20 bbl. per day. Just what this well could produce if pumped steadily is entirely problematical. It has never shown any signs of weakening, but it has never been necessary to call upon it for heavy production. I was told that on one afternoon it produced 25 bbl. of oil within a few hours to meet some special demand. The Arcola company was drilling a third well, using an American drill of 500-ft. capacity. This company uses oil for fuel.

The Connecticut Oil Co. was drilling a well, using a No. 5 Columbia rig. This well is situated about 1½ miles southwest of the rig of the San Francisco & San Juan Oil Co. At the time of my visit the well was down about 80 feet.

The Navajo Oil Co. had a No. 5 Columbia rig set up on ground close to the foot of a local landmark known as Jacob's Staff, and practically at the bottom of the main syncline. This well was down 500 ft. when I left the field. Water had first been found at 138 ft., with a second flow at 225 ft. At 310 ft. the sand bailer showed slight traces of oil. At 500 ft. the Goodridge sand had not been found. Geologically, the ground upon which this rig is situated is considerably higher than much of the other ground already mentioned, despite the fact that it is near the bottom of the main syncline.

The Monumental Oil Co. has drilled several shallow wells in various parts of the district. A No. 00 Star drill (rated capacity about 150 ft.) is used. This rig was on ground about 1½ miles northwest of Bell Butte, but at the time of my visit operation had been temporarily suspended. When running, this rig uses oil as fuel. This company has a contractor drilling for it with a No. 5 Keystone rig, on land situated about one-fourth mile to the east of the Mexican Hat, and lying nearly at the bottom of the main syncline, not far from the river's edge. This rig uses oil as fuel.

The Redwood Oil Co. has drilled two or three shallow wells on ground lying about two miles northeast from the rig of the London & San Juan Oil Co. According to the best information I could obtain, it is questionable whether any real showing of oil had been found. A 16-hp. Dempster drill, which, when running, uses gasoline as a motive power, was used. At the time of my visit it was temporarily idle. The rated capacity of the rig is probably about 300 feet.

Ashenhurst, known locally as the Ashenhurst Camp, is controlled by Colorado Springs men. At the time of my visit the camp was deserted, operations having been suspended for some time. A No. 27 Star drill in poor repair was on the property, and, when running, wood was used as fuel. One shallow well about 60 ft. in depth had been drilled, and the rig was set up over another well, stated to be about 150 ft.

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deep. It is claimed gas was found in the first well, and a slight showing of oil in the second. The rig is about two miles northeast of that of the Redwood Oil Co. This company also brought in an American rotary drill, which, however, after being placed on the ground was never used.

Two of the McGee wells are situated near the bottom of the main syncline, near a local landmark known as the 'Golden Gate.' The first well drilled was comparatively shallow, and much water was found, with perhaps a slight showing of oil. The second was drilled to a depth of approximately 1045 ft. Owing to the fact that the ground on which this rig was then drilling is geologically several hundred feet higher than that farther up the anticline, the Goodridge sand was not found until considerable depth had been reached. Just where the Goodridge sand was cut in this well, I was unable to determine; but it was current report that at 800 ft. a good showing of oil had been found; enough to give a good scum of oil on the bailing wire. There was a great deal of water in this well, and as but little casing was used, the detection of oil was a difficult matter. Both of these wells were drilled with a No. 4 Keystone rig, burning wood as fuel. At the time of my visit the camp was temporarily deserted, but Mr. McGee returned a day or two before I left, and stated that he was going to move the rig to another part of his holdings and again begin drilling.

The Norwood & Bluff Oil Co. is locally known as the Galloway Brothers company. A Standard rig is now operating on land in John's canyon, about twelve miles by air-line northwest of the townsite of Goodridge. The well, at the time of my visit, was down slightly over 1400 ft. The canyon of the San Juan river at its nearest point (probably three miles from the well) is about 1500 ft. deep, I was informed. The Galloways planned to sink this well, if possible, to a depth of about 2000 ft., in order to prospect the ground. Mr. Galloway informed me that at a depth of 85 ft. an oil sand (supposed to be the Goodridge) was cut and that it gave a good showing of oil. About a gallon of this was recovered by the bailer, and it appeared to be of the same general quality noted in the Goodridge and Arcola wells. At 640 ft. another showing of oil was found, though not quite as strong as at 85 ft. At 1170 ft. another oil sand was cut, giving approximately the same showing as the 85-ft. sand. It is entirely possible that any one of these sands, if properly shot, would result in the bringing in of a fair pumping well.

In addition to the above mentioned operations, there were several companies preparing for actual development work. On my way out I met a new No. 28 Star drill which was being taken into the field for the Chicago Development Co. At Dolores, I met two gentlemen who were expecting drilling rigs to arrive any day. One of these was a No. 25 Keystone for the Aztec company; the other one being a No. 24 Star drill for the Utah Paraffine Oil Co.

One important feature that must not be overlooked in connection with these fields is that in October 1909 the United States Government withdrew from further entry all lands in this district that had not been properly located before that date. It is easy to understand why, of the 30 or more wells drilled, so many shallow wells have been put down, and, comparatively, so few deep ones. It has been, and still is perhaps, the general custom of operators in the field to drill only deep enough to

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610 ft.; the drill passing through 17 ft. of oil sand at the bottom of the well, and into 18 in. of a firm rock, stated to be much like jasper. This lowest oil sand is supposed to be the Mendenhall. The well was shot early in June of 1911, using 50 lb. of 60% dynamite. The bottom of the casing was seriously damaged by this shooting, and for a time the well was practically closed. The operators finally succeeded in getting it opened, and since that time it has been the best well thus far drilled in the field. It is equipped with a Fairbanks-Morse pumping engine, and it is now regularly supplying four and sometimes five drilling rigs with fuel oil. Since being shot, this well has produced perhaps 500 to 600 bbl. of oil, and when I was in the field was regularly producing 10 to 20 bbl. per day. Just what this well could produce if pumped steadily is entirely problematical. It has never shown any signs of weakening, but it has never been necessary to call upon it for heavy production. I was told that on one afternoon it produced 25 bbl. of oil within a few hours to meet some special demand. The Arcola company was drilling a third well, using an American drill of 500-ft. capacity. This company uses oil for fuel.

The Connecticut Oil Co. was drilling a well, using a No. 5 Columbia rig. This well is situated about 1½ miles southwest of the rig of the San Francisco & San Juan Oil Co. At the time of my visit the well was down about 80 feet.

The Navajo Oil Co. had a No. 5 Columbia rig set up on ground close to the foot of a local landmark known as Jacob's Staff, and practically at the bottom of the main syncline. This well was down 500 ft. when I left the field. Water had first been found at 138 ft., with a second flow at 225 ft. At 310 ft. the sand bailer showed slight traces of oil. At 500 ft. the Goodridge sand had not been found. Geologically, the ground upon which this rig is situated is considerably higher than much of the other ground already mentioned, despite the fact that it is near the bottom of the main syncline.

The Monumental Oil Co. has drilled several shallow wells in various parts of the district. A No. 00 Star drill (rated capacity about 150 ft.) is used. This rig was on ground about 1½ miles northwest of Bell Butte, but at the time of my visit operation had been temporarily suspended. When running, this rig uses oil as fuel. This company has a contractor drilling for it with a No. 5 Keystone rig, on land situated about one-fourth mile to the east of the Mexican Hat, and lying nearly at the bottom of the main syncline, not far from the river's edge. This rig uses oil as fuel.

The Redwood Oil Co. has drilled two or three shallow wells on ground lying about two miles northeast from the rig of the London & San Juan Oil Co. According to the best information I could obtain, it is questionable whether any real showing of oil had been found. A 16-hp. Dempster drill, which, when running, uses gasoline as a motive power, was used. At the time of my visit it was temporarily idle. The rated capacity of the rig is probably about 300 feet.

Ashenhurst, known locally as the Ashenhurst Camp, is controlled by Colorado Springs men. At the time of my visit the camp was deserted, operations having been suspended for some time. A No. 27 Star drill in poor repair was on the property, and, when running, wood was used as fuel. One shallow well about 60 ft. in depth had been drilled, and the rig was set up over another well, stated to be about 150 ft.

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deep. It is claimed gas was found in the first well, and a slight showing of oil in the second. The rig is about two miles northeast of that of the Redwood Oil Co. This company also brought in an American rotary drill, which, however, after being placed on the ground was never used.

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get a so-called 'showing' of oil (often only enough to appear as a slight stain of oil on the surface of the bailing water). This showing has been regarded as discovery oil, and as sufficient proof to hold their land. When such showing was found the drilling rig would be moved to another part of their holdings.

The fact that the crude oil, just as it comes from the well, is being used as gasoline to run two small pumping engines, speaks conclusively for its quality. An analysis made some time ago for A. C. Ellis, of Salt Lake City, who controls the Oil Company of San Juan, of oil coming from the Goodridge well No. 1, gave the following results:

	Temp. Deg. F.	Temp. Deg. C.	Per Cent. Vol.	Per Cent. Wt.	Gravity. Deg. B.	Gravity. Sp. Gr.
Naphtha	70-250	21-121	12.5	11.0	66	0.75
Light burning oil	250-400	121-204	31.2	19.9	51	0.78
Heavy burning oil	400-500	204-260	19.2	19.0	41	0.83
Heavy oils	500-up	260-up	43.0	44.6	33	0.87
Coking and loss	.....	.....	4.1	5.5	..	...

An analysis made for me some months ago by F. E. Knoch, superintendent for the United Oil Co., of Florence, Colorado, on a sample of oil taken from the Arcola well No. 2, by A. H. Spencer, gave the results following. This sample had been exposed to the atmosphere in an open can for more than a month, and consequently a certain portion of the lighter constituents had possibly volatilized.

Color, dark green. Gravity, 35.5° Beaume. Boiling point, 240°C.

Per Cent.

15 Naphtha 12% gasoline; 3% varnish-makers' and painters' gasoline.

35 Kerosene of 44° gravity, 110°C. fire test.

5 Mineral Seal oil, 300°C. fire test.

42 Fuel oil.

3 Loss.

This oil contains about 2% paraffine wax and ½% asphaltum.

In conclusion, it may be pointed out that the geology of this district is unquestionably favorable to the occurrence of petroleum. Furthermore, the presence of a certain amount of oil of splendid quality has been proved. Whether a sufficient quantity of oil will ultimately be developed to warrant the building of adequate transportation facilities—either a pipe-line or a railroad, or both—and thus to make the industry commercially successful, can only be determined by continued drilling. The development work has given most promising returns.

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Centrifugal Pump Testing

By OSCAR C. GOERIZ*

CENTRIFUGAL pumps are commercially rated by their discharge diameter, as a matter of convenience. This method is crude, and to the uninitiated it must appear that the manufacturer who has adopted 12 to 15 ft. per second discharge velocity, turns out a superior grade of pump to that made by another factory which bases its capacity ratings on the more conservative velocities of only 8 to 10 ft. per second. In fact, all other items being equal, the pump scroll of smaller size must give more friction and reduce the efficiency correspondingly.

The essential element of a centrifugal pump is the impeller or runner, but for two pumps of the same nominal rating, the runner diameters which principally govern the available lift may differ widely. If both pumps were operated with the same number of revolutions and under equal lift, the one with the larger runner would certainly discharge far more water, unless its ports were much restricted. While the reciprocating piston or plunger pump, rated by the size of its essential working parts, and giving a known positive displacement per revolution, permits of close calculation as to the performance that may be expected under a definite head and speed, the conditions are far more complex for a centrifugal pump. The various dimensions of the runner and its vanes must be known, as well as the shape of the scroll and diffusor, before one could attempt to determine the probable discharge, lift, and horsepower requirements at a certain speed. It is therefore desirable for the buyer to have his centrifugal pump tested under the actual conditions of operation, whereas it might be considered an unnecessary luxury to have a reciprocating piston or plunger pump specially tested before it was shipped and installed.

The general arrangement for carrying out a fairly accurate test is a comparatively simple matter, and unless the centrifugal pump is of very small size, or is to be used for a short period only, it will pay to make a thorough test. This test should determine the pump efficiency, which is the ratio between the useful performance and the energy input measured at the pump shaft while the latter is running at a certain speed, and under conditions of lift duplicating those under which the pump is to be operated in the future. This indicates clearly what measurements should be taken.

The WHP (water-horse-power) depends upon the weight of water lifted per second, and upon the height of lift. In most instances the total lift consists of four parts: (1) entrance and friction losses in suction pipe; (2) suction lift; (3) pressure lift; (4) friction in the discharge pipe. For very accurate tests the pump is credited with the difference between the velocity heads in the discharge and suction pipes. If both pipes

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are of equal size the vacuum gauge reading takes care of the whole allowance on account of velocity.

If Q denominates the discharge volume in cubic feet per second, and H the total lift in feet, then for clean water:

$$1. \quad WHP = \frac{62.5 \times Q \times H}{550} = \frac{Q \times H}{8.8}$$

Or if the volume is measured in gallons per minute G, the useful work in horse-power must be:

$$2. \quad WHP = \frac{8.33 \times G \times H}{33{,}000} = \frac{G \times H}{3{,}960}$$

and if the input in BHP (brake-horse-power, or effective-horse-power) is known, the pump efficiency (e%) is:

$$3. \quad e\% = \frac{WHP}{BHP} \times 100$$

The following items, therefore, must be determined, and convenient methods for obtaining them will be briefly discussed:

a Water weight lifted per unit of time.

b Total height of lift.

c BHP input into the pump.

d Speed of the pump shaft.

Because of the peculiar manner in which the impeller handles the water, it is necessary in a shop test to vary the lift by throttling the discharge while the speed is kept constant, so that the relation between lift and volume of discharge will be exactly known. The results must be tabulated and entered in a diagram, which represents the 'characteristic curve' of the pump for a given constant speed. (See curve No. 1 in Fig. 1.) After the pump has been primed and started, the discharge may be closed, so that the water will be merely churned. According to the prevailing designs of the runner blades, the lift corresponding to the condition of 'no-discharge' will come close to the maximum obtainable pressure. Another important point on the curve is the maximum discharge obtained for the condition of 'no-lift'. In both extreme cases the useful work is indicated by 'zero', and the curve No. 2 in

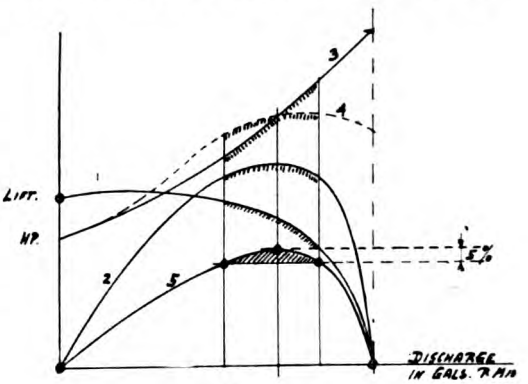

FIG. 1.

Fig. 1 can be plotted to represent the WHP for useful work, figured from formula **2**. With increasing speed of flow due to variation of the lift, the WHP will also grow until a certain maximum of WHP is reached, when the WHP will be reduced again until it reaches the zero-point. The BHP curve, No. 3 in Fig. 1, must be plotted carefully. For a direct coupled electric motor, the kilowatt readings which correspond with the various points of curve No. 1 should be noted. By an independent brake test the BHP which conforms to the said kilowatt readings must be determined. The BHP input at the pump shaft is always a minimum for the point of 'no-discharge'. It is evident that the BHP requirements will rise as soon as flow is established and useful work performed, and that the BHP must increase to a certain maximum. This maximum may be found right at the point of maximum flow, but it is evident that it is more desirable to have

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a BHP curve of such a nature that the maximum is reached before the maximum flow is obtained, which would necessitate a runner having the non-overload feature. This is illustrated by the dotted curve No. 4.

The efficiency is figured from equation **3**, and the curve No. 5 will show the most efficient field of application for the pump at the known speed. The maximum efficiency is obtained for a certain lift and volume of discharge, but if a small drop of efficiency of as little as 5% is allowed, the lift and the corresponding discharge can be varied between certain limits as shown in Fig. **1**.

a MEASUREMENT OF THE WATER.

1. If the capacity of the pump is small, the best and also the most exact method consists of the direct measurement of the weight of water delivered in a certain length of time. A tank is placed upon a platform scale and the time which is required to deliver a certain weight of water is taken by a stop-watch. Thus the weight in pounds per second is easily obtained. At the known constant speed of the pump runner, and for a fixed definite lift which shall not be altered during the specific test, the average weight of water per second is established with great accuracy and beyond dispute.

2. Practically the same degree of accuracy is reached if the pump which is being tested is used to fill a tank of known size and capacity, so that the volume in cubic feet per second can be calculated.

3. A convenient way to determine a volume of discharge, which may range between 100 gal. per min. and 100,000 gal. per min., is afforded by the overfall or weir with full contraction. The smaller or larger flow, being subject to physical laws, will produce a corresponding head over the crest of the weir. By measuring the latter, the volume can be found by calculation, as shown by Fig. 2. If b designates the

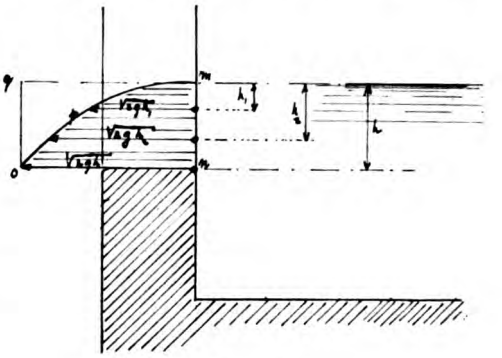

FIG. 2.

width of a weir and h the height of the water-level above the crest, in a weir without contraction every head h_1, h_2, etc., should produce a velocity: $\sqrt{2gh_1}$, $\sqrt{2gh_2}$, etc. For the maximum head h, the velocity would amount to $\sqrt{2gh}$. The values of velocities can be entered in Fig. 2, or they may be shown in the perspective sketch Fig. 3.

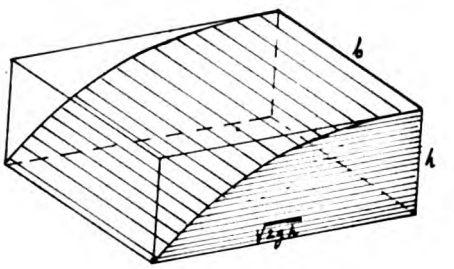

FIG. 3.

The curve of velocities is a parabola and the area m-n-o-p-m is ⅔ of the rectangle m-n-o-q. If the water should shoot through the orifice bh with the uniform velocity $v = \sqrt{2gh}$ the volume would be $bh\sqrt{2gh}$, but the theoretical volume Q shaded off in the perspect-

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ive sketch and depending upon the variable water velocities is:

4. $$Q = \tfrac{2}{3}bh \times \sqrt{2gh}$$

For the overfall with full contraction (Fig. 4) the said velocities will be diminished, and if y is introduced into the above formula as a coefficient of

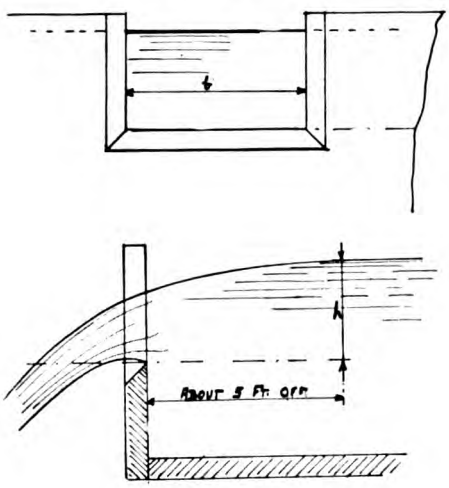

FIG. 4.

reduction, the actual volume of discharge is found to be:

5. $$Q = y\tfrac{2}{3}bh \times \sqrt{2gh}$$

The edges of the overfall should be beveled off at the downstream side, as indicated in Fig. 4. The value of coefficient y which depends upon the condition of the edges, is further influenced by the width and depth of approach, the width and height of the overfall, and finally by the velocity of approach, and by the direction of the wind if tests are made in the open. The value of $\frac{2}{3}y$ is generally between 0.38 and 0.43. The formulas of Francis or of Smith-Francis, which are more often used, give results in close harmony with the equation **5**, but they do not show so plainly how they have been derived.

4. The Venturimeter, especially the type used in combination with a discharge recorder, is of great convenience for waterworks or any installations where it is desirable to check the flow at frequent intervals. This apparatus is a combination of a short and a long conical pipe, the principle being shown in Fig. 5. At the section 1 the velocity

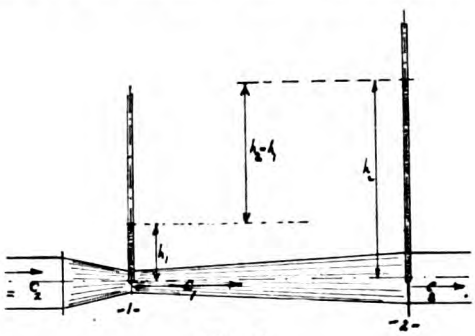

FIG. 5.

is highest, and it will gradually slow down to the original velocity again at section 2. Neglecting the small friction loss between sections 1 and 2, the sum of kinetic and potential energies must be equal for both sections, when:

6. $$h_1 + \frac{C^2_1}{2g} = h_2 + \frac{C^2_2}{2g}$$

The pressures h_1 and h_2 are measured in feet direct, as the height of the water in small standpipes, as mercury columns in the same way, or by suitable pressure gauges.

If we assume that the ratio of the diameters at both sections be 1 to 4, the areas will have the proportion of 1 to 16, the velocities 16 to 1, and the squared velocities, therefore, 256 to 1. For this particular assumption the formula **6** would be changed to:

$$h_1 + 256\,\frac{C^2_2}{2g} = h_2 + \frac{C^2_2}{2g}$$

then $$h_2 - h_1 = 255\ \frac{C^2_2}{2g}$$

But we can substitute 256 for 255 and

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obtain an accuracy within ½% and write:

$$\frac{C^2_1}{g} = h_2 - h_1; \text{ or}$$

$$7. \qquad C_1 = \sqrt{2g\,[h_2 - h_1]}$$

Thus the volume will be found as the product of the velocity C_1 by the area of the section at point 1.

5. The Pitot tube (Fig. 6) inserted

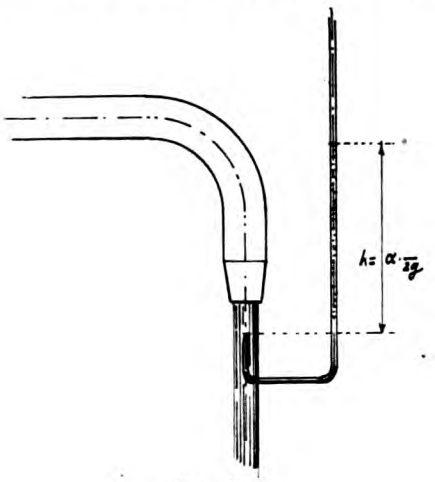

FIG. 6.

at a discharge nozzle measures the velocity head, subject to slight correction, and the volume of discharge can be checked with convenience, particularly if overfall readings are made at the same time.

6. For very large canals or ditches fed by centrifugal pumps, it may be practically impossible to establish a contracted weir. The use of a float to obtain the velocity of flow gives unsatisfactory results, inasmuch as the velocity of the float is not the average velocity in the canal, and it is therefore necessary to make a correction, the accuracy of which is problematical. Current wheels or current meters give better results provided that they are properly calibrated before and after the test, and that a large number of readings is made all over the profile while the speed and lift of the pump are not changed.

b MEASUREMENT OF THE HEIGHT OF LIFT.

One essential point, which is generally neglected, is the determination of the greatest vacuum which can be obtained, also the influence of the partial vacuum on the pump efficiency. Fig. 7 indicates how the conditions of suc-

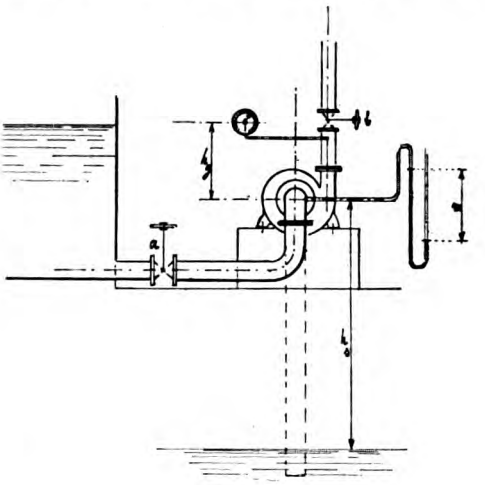

FIG. 7.

tion which will obtain after the installation of the pump at the site of the purchaser, can be duplicated at the factory by throttling at the valve, a, until a mercury column, m, will show the desired amount of suction. (One inch vacuum measured in mercury column equals 1.133 ft. of suction lift.) To this suction head must be added the distance h_g from the level of the shaft to the centre of the pressure gauge, provided that the connection to the mercury column is made so that there is no water in the space, s. If it were filled with water, a corresponding correction should be made, because, m, would show less mercury column due to the water leg resting on one side. By setting the valve, b, for the pump discharge, any

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desirable change of pressure lift can be obtained. The total lift is found to be:

8. $$H = h_s + h_g + h_d$$

If the discharge head is measured in pounds per square inch, this figure should be multiplied by 2.31 to transpose this head into feet of water column.

c MEASURING THE BHP INPUT INTO THE PUMP SHAFT.

Only a regular testing-room can afford to have a torsion dynamometer, which certainly is the best way to learn the exact BHP input. The principal function of this apparatus is the measurement of the torque or twisting moment which is transmitted to the pump. This torque can be measured, for instance, by the calibrated deformation of a helical spring, arranged in such a manner that the relative angle of deformation will be indicated by the instrument. Fig. 8 exemplifies the

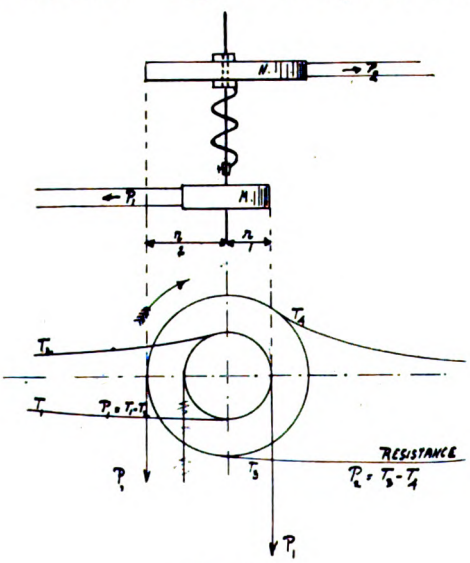

FIG. 8.

method. A pulley M keyed to the shaft is operated by belt from any prime mover or motor. A loose pulley N is connected to the same shaft by means of a helical spring, and a belt laid on this loose pulley drives the pump. The fast pulley may have a radius r, and the force of the belt be P_1, while the loose pulley may have the radius r_2 and resisting force P_2. Neglecting the friction of the shaft in its bearings, both torques must be equal, or:

9. $$P_1 r_1 = P_2 r_2$$

This torque is indicated by the and the deflection (Fig. 9). Writing angle of

FIG. 9.

the formula for the BHP, it is evident that

10. $$BHP = 2\pi r \frac{n}{60} \frac{P}{550}$$

where n designates the revolutions per minute, and rewriting the formula to express the torque:

11. $$P r = P_1 r_1 = P_2 r_2 = \frac{33{,}000}{2\pi} \frac{BHP}{n}$$

The spring can be easily calibrated, marking off the deformation which corresponds with various weights attached to the periphery of the loose pulley.

The process of ascertaining the BHP of an electric motor has been described above. For steam engines and gasoline engines indicator cards should be taken and these being referred to previous brake tests will disclose the BHP transmitted to the pump shaft.

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Formula **10** can be used for the brake tests, as in this case the friction moment of a strap laid around a pulley is determined by traction dynamometer, or, as the force acting on a platform scale at the end of a brake beam multiplied by the length of the beam.

d MEASURING THE SPEED OF THE PUMP SHAFT.

The diameter of a centrifugal pump runner and the number of revolutions per minute are both of the greatest consequence as far as the available lift is concerned. A runner half the size of another, but having twice the number of revolutions, should give approximately the same lift or pressure as the first one. For finding the BHP according to equation **10** the speed of the shaft must be known, and in belted pumps it is very desirable to ascertain the slippage loss, as this is a part of the energy loss of the belt drive, by comparing the speeds of both shafts and determining the theoretically available pump speed by the pulley diameter ratio.

Common speed counters are liable to slip, unless provided with rubber points, but at best such a method is crude and inaccurate. The belted tachometers indicating the speed instantaneously give far better results if properly calibrated, and they show whether there is any irregularity of speed such as will be found in a gasoline engine driven pump. The electric tachometer, either direct-connected to the pump shaft or operated by rigid gearing from the same, has the great advantage of doing away with the necessity of making corrections for the slippage of a belt, and assists materially in verifying the speed and power input of a pump, which are just as important as the correct checking of the useful work represented by an accurately determined weight of water lifted to an accurately measured total lift.

WHERE EFFICIENCY IS UNIMPORTANT.

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The Engineering Digest

Reinforced Concrete Highway Bridges

AMONG interesting features of the third annual report of the Illinois Highway Commission is a series of descriptions of small concrete bridges of different types, which the Commission has been building. We present below items regarding methods of design, character of concrete, and forms.

Probably a majority of the bridge sites in Illinois afford only a low clearance or headroom. Foundations usually must rest on earth; in many instances it becomes necessary to drive piles, in order to give sufficient bearing. It is exceptional that the rock approaches near enough to the surface to found the abutments on it. It became necessary to adopt such a design as would give a maximum clearance and waterway, at the same time adapted to an earth foundation. To meet these conditions, therefore, a through girder concrete bridge was developed; that is, a bridge supported by two girders to which the floor is hung; in this way using a minimum of clearance and giving a maximum waterway for a given distance between abutments.

This type of bridge has its limitations. A bridge supported by two girders to which the floor is hung is limited as to width of roadway for a given span and also as to length of span. It was found, however, that where the roadway is not required to be over 18 to 20 ft., this type of bridge proved economical up to spans 40 to 60 ft., as compared with arches having the same area of waterway and designed to carry the same loads. While the tops of the girder bridges are heavier than would be required for arches, yet, owing to the fact that there is no horizontal thrust, the abutments do not need to be as extended or made as heavy. There is, therefore, less concrete for the width of roadway named, taking the abutments and superstructure as a whole, in the through girder design than in arches giving the same area of waterway and capable of supporting the same loads. In appearance the girder bridges are massive and well adapted to their apparent purpose, having in general a not unpleasing outline.

Perhaps the greatest advantage possessed by the girder type over the arch is the slight damage, if any at all occurs, to the former due to uneven settlement of the abutments as is apt to occur in many of the soil conditions encountered; while, on the other hand, such displacement of the abutments of an arch is extremely hazardous to its stability. These are the reasons for designing nearly all concrete bridges of the through girder type, not that this type is necessarily to be preferred in all locations, or under all conditions, but merely that it has proved most economical in nearly all instances in the practice of the Commission.

The formulae used in the design of these bridges have been reduced from the general formulae developed by A. N. Talbot and others. The form in which they are used is that most convenient for purposes of bridge design. The first fact to determine is the stress to be allowed in the concrete and the steel, which, when once fixed, determines the percentage of steel reinforcement. The compression allowed in the concrete has been taken at 750 lb. per sq. in. for concrete 60 days old, with a corresponding stress in the steel in tension of 16,000 lb. per sq. in. This corresponds to practically 1% reinforcement.

To compute the dimensions of a girder to withstand a given bending moment, M, where b is the breadth and d the depth, from the top of the beam to the centre of gravity of

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the steel, using the above stresses in the concrete and steel,

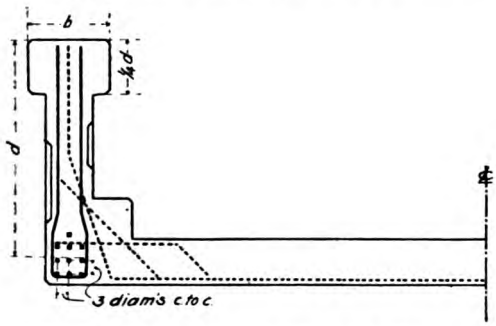
$$M = 0.833 \times 16{,}000\ bd^2 \times 0.01.$$

Usually b is assumed and d is to be found; then this reduces to the simple form

$$d = \sqrt{\frac{M}{136b}}$$

For computing the depth of T beams (see the figure below), the width of the flange b is assumed and the depth is then computed by the above formulae, but always making the depth of the flange not less than one-fourth of the value found for d.

To provide against diagonal tension in the webs of beams, U stirrups are used where the shear in the concrete exceeds 30 lb. per sq. in. The amount of steel to be provided is found thus: Let V be the total shear in a given section of the beam. The steel stressed at 16,000 lb. per sq. in., necessary to carry six-tenths, V is distributed along the beam for a distance equal to the height of the beam $= d$. For example, if $V = 200{,}000$ lb., $0.6\ V = 120{,}000$ lb., which would require 12.5 sq. in. of steel. If the value d of the beam is 60 in., there is required 12.5 sq. in. of steel for 60 in., or 0.208 sq. in. of steel per inch of girder. A U-shaped stirrup of ¾-in. section rods would have in both legs 1.12 sq. in. of steel, which divided by 0.208 will give the spacing for the U stirrups, which in this case would be about



TYPICAL CROSS-SECTION THROUGH GIRDER REINFORCED CONCRETE BRIDGE.

5 in. for the first 60 in. along the beam. In the next section, a new value for the shear would be computed and the rods and stirrups accordingly, as the shear is usually computed for sections which are arbitrarily spaced along the beam equal to its depth d.

The thickness of the web of the T beams should be investigated for horizontal shear. Usually, however, the governing factor in determining the thickness of the web is the space required for the reinforcing rods.

The loads for all concrete bridges are taken thus: Dead loads concrete at 144 lb. per cu. ft., crushed stone at 90 lb., and earth at 100 lb. per cu. ft. Live loads are uniform 125 lb. per sq. ft. and concentrated live loads of 24 tons distributed on two axles, 10 ft. apart, 8 tons on the front and 16 on the rear axle. The load is taken as applied over a width of 12 ft. The moment for both uniform and concentrated live loads is computed, and the greater combined with the dead load moment to determine the girder and floor dimensions.

The character of concrete employed in the bridges under discussion is a factor governing the cost. It will be noted that the specifications provide for a 1:2½:4 mixture for reinforced work. This proportion was determined upon after considerable experience with a 1:2½:5 mixture, which did not secure an altogether satisfactory finish. As much of the surface of the concrete is exposed in bridges, a smooth, close-grained surface is particularly desirable. If a smooth finish is to be secured in concrete work, it is necessary, first, that the forms be carefully made and kept true to alignment; second, that the concrete shall contain sufficient mortar to more than fill all voids in the stone. This is not secured satisfactorily when the proportion of mortar to the stone is one-half, as is the case in a 1:2:4, 1:2½:5, or 1:3:6 concrete. The specifications were therefore changed so that the proportion of mortar to the stone varies with different classes of concrete, according to the purpose for which it is to be used. In reinforced work we have endeavored to use a concrete which will have a volume of mortar about equal to 60% of the volume of the stone. Such an amount of mortar is necessary where the concrete must be placed around the reinforcing rods and molded closely against the forms, which are not a great distance apart. Under these conditions, if honeycombed effect is to be avoided with the workmanship ordinarily secured, concrete with more than 50% mortar should be used. In gravel concrete, the amount of cement to be used is proportioned according to the amount of sand; the amount of sand that may be allowed depends upon the voids in the stone, mortar being supplied to at least 60% of the total volume of the stone for use

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in reinforced work. Stone for this class of construction, moreover, should not exceed one inch in size if it is to be satisfactorily placed about the reinforcement.

While the specifications do not call for any particular kind of reinforcement, other than that it must have some means of rigid mechanical bond at frequent intervals, as a matter of fact nearly all the work so far done has employed square twisted rods.

The specifications and drawings provide for rigid forms. Particular attention is paid to the bents supporting the structure during construction. It is evident that great care must be exercised to prevent any settlement of the girders while the concrete is hardening, when it is borne in mind that, for spans of 40 to 60 ft., the girders and floor weigh six to seven tons per running foot. The plans for the longer spans require that the bents supporting the forms shall rest on piles firmly embedded, unless the stream bed is of such a character as to make this unnecessary. But such a condition is the exception. In a number of instances the contractor has put in concrete floorings flush with the bottom of the stream bed and has placed bents direct on them.

Dehydration of Crude Petroleum

THE electrical process of dehydrating crude petroleum is discussed informingly by Arthur T. Beazley, in a reprint from the *Oil Age*, recently distributed. It will be remembered that in almost all oilfields water-bearing strata are found either above, below, or between the oil-sands, and the exclusion of the water from the 'pay' sands is admittedly one of the most important, and also most difficult, problems before the oil operator. In cases where shutting off the water has not been properly accomplished, a fair production may be secured from the well for a comparatively short time, owing to the pressure of gas on the oil; but when the gas pressure decreases, the column of oil is gradually lowered until the pressure due to it becomes less than that due to the natural water-head, and the water will then flow into the well and mix with the oil.

It is sometimes possible to re-cement the well, but not usually, and the operator must either abandon the well (after properly plugging to protect the oil-sand) or produce the water along with the oil. The use of an air-compressor sometimes enables him to remove the water as fast as it comes into the well, and so protect the surrounding 'pay' sands, but produce the water he must. This water may be in one of several conditions; it may be 'free', in which case it will readily separate from the oil in the tanks or sumps, or it may form a complete 'emulsion' with the oil, in which condition it cannot be settled. A third condition is that of 'partial' emulsion, some of the water being 'free' and some emulsified. In California a typical complete emulsion is easily recognizable by reason of its reddish color, but in doubtful cases a rough estimate of the degree of emulsion may be made by taking a drop of the oil and squeezing it between two pieces of thin glass, such as microscope slides. Under these conditions 'free' water will appear in the form of large clear globules scattered through the oil, while an emulsion will present the appearance of a comparatively homogeneous field, the water particles being small and distributed evenly.

At some time previous to 1908, F. G. Cottrell successfully accomplished the precipitation of suspended solids in gases by means of high potential electricity. The applicability of the same methods to the precipitation of water in a petroleum emulsion was then suggested, and gave rise to a series of experiments in which Mr. Cottrell was joined by Buckner Speed. The results of these experiments led to the building of a plant for the dehydration of crude petroleum on the property of the Lucile Oil Co., in the Coalinga field, early in 1909. This plant has been in continuous operation ever since, reducing a 14% water-content to less than 2% with commercial success.

An experimental plant was next built on the property of the Western Union Oil Co. in the Santa Maria field, in order to investigate the possibilities of the process as applied to rebellious coast oils carrying a high percentage of water. The capacity of this plant was not enough to give any results on a commercial scale, but a large quantity of valuable data was obtained. The next

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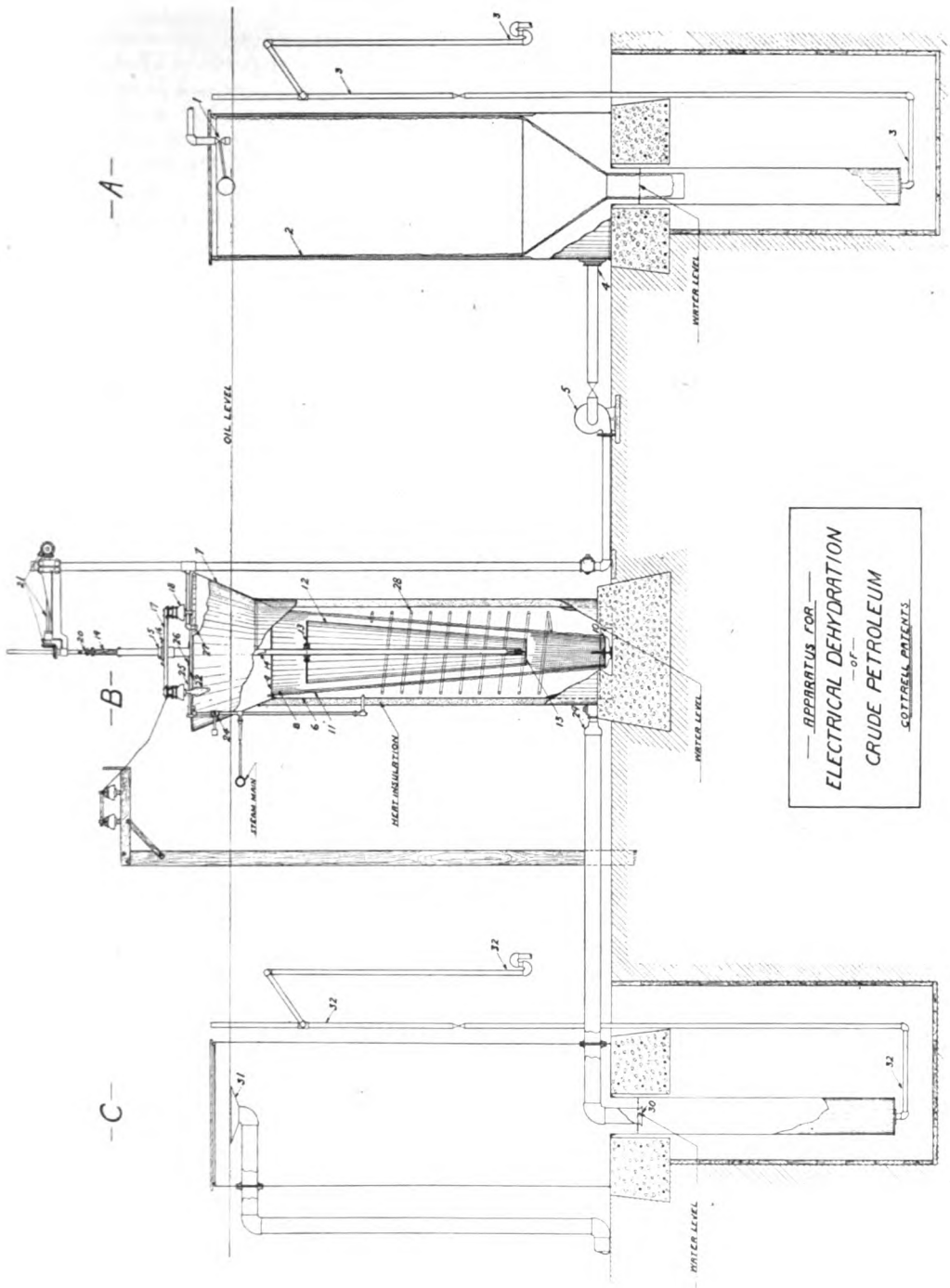

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step was the erection of apparatus on a fairly large scale on the property of the Pacific Oilfields, Ltd., near Lompoc, during the first half of 1910. This plant was built by Mr. Beazley with the help of A. C. Wright. As originally designed, the treaters in this plant were essentially the same as those which had proved satisfactory in the Lucile Oil Co.'s plant. It was found, however, that the type of electrode used, a stationary one, was not adapted to the rebellious and heavily emulsified coast oil now to be rectified. A new form of electrode, now the standard, was devised. It is shown in the accompanying figure.

The complete apparatus consists essentially of three units, the Wetted Septum Water Trap *A*, the Electrical Treater *B*, and the final Water Trap or Separator *C*. The Wetted Septum Water Trap is only installed in cases where the emulsion is incomplete and is intended to remove, rapidly and inexpensively, that portion of the water which is free. It obviates the necessity of large tanks or sumps, with their attendant losses by evaporation and seepage.

Assuming that a partial emulsion is to be treated, the operation is as follows:

The oil is first allowed to flow through the Wetted Septum Water Trap *A*, and during its passage through this trap the free water is deposited on the wetted septum 2 and passes down it to the bottom of the trap and so away through outlet 3, which is so adjusted as to height as to make it self-regulating. The desired oil level in the trap is maintained by means of float valve 1, which controls the supply. From this trap the oil and water emulsion is discharged through outlet 4, whence it is taken by the rotary pump 5 and delivered to the treaters *B*. In cases where the contour of the ground permits, the Wetted Septum Water Trap may be placed at an elevation above the treaters, thus securing gravity feed and making rotary pump 5 unnecessary. The wetted septum 2 is merely a pervious canvas bag which has been thoroughly wetted with water, and is long enough to reach below the permanent water-level in the lower element of the trap. Under these conditions the canvas has an affinity for water, but not for oil. When the mixture of emulsion and free water, in its passage through the trap, reaches the canvas, the emulsion passes through, while the water, for which the canvas has an affinity, is deposited on and drawn down the canvas to join the main body of water. The treaters *B* consist of a sheet-metal tank 6, cylindrical for the major part of its height, but having an inverted conical top portion 7. The object of this increase in diameter near the top is to lengthen the distance between the electrodes along the surface of the oil, and thus prevent surface leakage.

An outer electrode is formed by tightly stretching a number of wires 8 from a ring 9 at the base of the inverted cone to a circular plate 10 fastened to the bottom of the tank. Outside this electrode is a wetted septum 11. An inner electrode is formed by tightly stretching wires 12 between two circular plates 13 suspended in the tank by vertical shaft 14. The wires of the inner electrode are parallel to, and exactly concentric with, the wires of the outer electrode. The inner electrode is supportd by a clamp 15 on the shaft 14, riding on a bearing saddle 16, which in turn is supported by the channel-iron frame 17 on insulators 18. The vertical shaft 14 is rotated through insulating shaft 19, and universal joint 20 by the shaft and gearing 21, the latter being operated by a small electric motor.

The treater has a cover 22 with a large circular opening in the centre through which the inner electrode passes. The top ring of the treater is made of pipe which is perforated with a large number of holes pointing horizontally, and which is connected through valve 24 to a steam supply; this valve is normally held closed by wire 25 and fusible link 26, but in the event of the oil in the treater catching fire, the fusible link will melt, releasing valve 24, and so filling the space below the cover with steam and choking the fire out. The oil enters the treater at inlet 27 (the flow being regulated by the size of the inlet orifice), and is maintained at a suitable temperature, depending on the viscosity, by means of a steam coil 28. After treatment the oil and water are discharged through outlet 29 and proceed to the separator *C*.

The inner electrode is connected through the saddle and frame with a source of electricity at a voltage between 10,000 and 15,000. The action of the electricity is to create a strong electrostatic field between the electrodes. As the emulsion under treatment comes between these electrodes the infinitely small particles of water, being conductors of

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electricity, will be formed into chains from electrode to electrode along the electrostatic lines of force, and, if the voltage be sufficiently high, the fine films of non-conducting oil between the water particles will be punctured, bringing the entire chain together in the form of one comparatively large drop. This drop is now free water and is deposited on the septum 11 and conveyed to the bottom of the treater. It may happen, however, that so many chains of water particles are formed at the same instant, that they constitute a short circuit between the electrodes, thus lowering the voltage below that point at which it can puncture the oil films. In order to prevent such short-circuiting, the inner electrode is rotated, which gives the desired result, probably owing to the lengthening of the chain between corresponding wires in the outer and inner electrodes as the latter is revolved.

The separator *C* is merely a device for quickly and automatically separating the oil and water. The mixture enters at inlet 30, and the clean oil rises and flows away to the delivery tanks through outlet 31, while the water drops and is discharged through pipe 32 in a clear stream. As in the case of the Wetted Septum Trap, the height of outlet 32 is so adjusted as to make the flow self-regulating, the controlling factor being the water-level in the lower element of the trap.

The output of a plant of this kind depends upon the characteristics of the oil, notably its gravity and viscosity and the percentage of water contained therein. The capacity per 24 hours of a treater working on a rebellious coast oil of 17 to 20°B. gravity ranges between 50 bbl. of a 50% emulsion and 150 bbl. or more of a 5% emulsion, while the capacity on the less rebellious valley oils will probably range between 100 bbl. of 50% emulsion and 400 bbl. of a 5% emulsion. The standard plant, as now designed, consists of one or two traps and four treaters, and has, therefore, a capacity somewhere between 200 and 1600 bbl. per day, depending on the oil to be treated. The design is such that additional treaters and traps can readily be added as the volume of production to be treated increases. Roughly speaking, 1 wetted septum trap will probably supply oil for 8 treaters when working on an average oil. One separator will take the product of 4 treaters efficiently, or as many as 8 in a somewhat less satisfactory manner, since its action is best at very low rate of flow, which does not disturb that quiescent condition of the oil which is most favorable for the complete settling of the water.

It is impossible to give any accurate estimate of the cost of a complete installation, since it will depend upon the size of the plant, the location, the local conditions, etc., but it may be noted that the cost of a complete treater will be in the neighborhood of $250, of a Wetted Septum Water Trap about $150, and of a Separator about $130. These figures do not include any piping, electrical machinery, or installation charges.

The consumption of electric energy per treater is a constant quantity, irrespective of the quantity or quality of oil passed through. This consumption is about 1200 watts, or approximately 29 kw-hours per day. In addition to this the power required to rotate the electrode at the necessary speed is about 330 watts, or approximately 8 kw-hours per day. The total power consumption per treater per day is, therefore, about 37 kw-hours. In the oilfields where cheap fuel is at hand, and frequently waste gas (costing nothing) is available, electric power can easily be generated for between one and two cents per kilowatt-hour. The exhaust steam from the generating plant can be used for heating the oil to the desired temperature, so that no extra charge for heating need be made. The cost of electric power and heating will thus be approximately 75 cents per treater per day. In cases where a hydro-electric power company's lines run close to the plant and the company is prepared to sell power at 2c. or less, the purchase of power might be desirable, but if the price asked is greater than the figure mentioned, the erection of an electric generating plant would be advisable.

The requisite attendance for the process under consideration is small, the chief item being a few minutes of one man's time once a day to grease gears and bearings, and to sample the incoming and outgoing oil. An occasional visit of inspection to see that the electrodes are rotating properly, and that the oil inlets and the water and oil outlets are unobstructed, is also essential. The only other labor required is for the renewal of the septums or canvas bags once every few months, an operation which might

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possibly consume an hour or two of two men's time.

The water content of the cleaned product is controlled, for a given initial water content, entirely by the rate of flow of the emulsion through the treater, and the oil delivered may be permitted to carry any desired water content from zero up, by regulating the size of the orifice in the oil inlet to the treater. The daily reports of the Pacific Oilfields, Ltd., plant show that on 60 consecutive workings days, with oil which carried a water content varying from day to day between 20% and 39%, the water content of the cleaned oil never once varied from the predetermined allowance of 1 per cent.

Water produced with oil is almost invariably heavily charged with mineral salts, and those who have had experience with refining or topping plants well know the annoyance and expense occasioned by the scale which these salts form in the stills. In the electrical process these salts are precipitated and the resultant product is pure oil, which, however, has lost none of its characteristic constituents or properties. The only change in the oil is that, owing to the removal of the water, the gravity of the cleaned oil is somewhat higher than that of the original emulsion.

The rights to this process for the state of California are vested in the Petroleum Rectifying Company of California. The basis on which the company issues licenses for the use of the process is that of a royalty on the amount of water extracted from the oil.

Fuel Resources of California

AT the March meeting of the Commonwealth Club of California, M. L. Requa, on behalf of the section on conservation, presented an interesting report upon the fuel situation in California. The complete paper has not yet been published, but a résumé is given below.

Natural gas, the ideal fuel, has been in use in California for many years. Nine counties produced it in 1910, the largest yield having been in Santa Barbara county, with over 9,000,000 thousand cubic feet. The San Joaquin county yielded over 300,000 thousand cubic feet, Sacramento county over 49,000 thousand, Kern county over 47,000 thousand, and the other five counties from 545 thousand to nearly 8000 thousand cubic feet. About 5000 oil wells give a daily yield of 50,000,000 cu. ft., or the equivalent of 1350 tons of coal. The Buena Vista Hills field, the only strictly gasfield of large magnitude in the state, has an estimated supply of 500,000 million cubic feet, or enough to supply San Francisco, with a 24-hour consumption of 14,000,000 cu. ft., indefinitely. It is quite possible that within two or three years the entire territory from Los Angeles to San Francisco will be supplied with this fuel. The production, transportation, and sale of natural gas should be so regulated as to conserve it and still supply it to the people at the lowest possible price. The subject is a new one in California and needs careful investigation, with study of other places where regulative legislation has already been enacted, before action is taken.

Oil is by far the most important fuel product of California, the yield having been over 78,000,000 bbl. in 1911. It is used exclusively for steam generation by all California railroads, practically all stationary power plants, and the great majority of coastwise steamships from Cape Nome in Alaska to Valparaiso in Chile. From proved areas aggregating approximately 100,000 acres, it is estimated that 4,255,000,000 bbl. will be recovered, of which over 3,795,000,000 bbl. is still in the ground. Estimates are made of 245,000 to 450,000 acres of additional possible oil territory in the state, with possible contents of 5,000,000,000 to 13,000,000,000 bbl. The United States Geological Survey gives California from one-third to one-half of all of the oil in the United States. The need of conservation in California is urgent. Present unsatisfactory conditions are due: (1) to line drilling; (2) inability to properly regulate marketing conditions because of the Sherman Act; (3) unsatisfactory control of water in fields; (4) uncertainty as to future policy regarding Government land. The throwing open of Government oil land at the present time would not only seriously affect present producers who are getting oil on the

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whole with little profit, but also tend to dissipate a resource that should be kept for later development. Government oil land should be leased only as its product is needed to supply existing wants and in such quantities as will not tend to glut the market. There is no reservoir equal to the underground reservoir.

Peat is known to exist in California, but there is a lack of data regarding it. Its occurrence is in the marshes of the Sacramento and San Joaquin deltas, in parts of Yolo and Sutter basins, throughout the marshes on San Francisco bay, in the marshes near the mouth of the Salinas river, and in that portion of Klamath lake lying in California. Estimates cover 72,000,000 tons proved in these areas, with possible additional areas containing 1,000,000,000 tons. Peat cannot compete with California oil, and apparently has no immediate value as fuel. It is believed that by the time it becomes a commercial possibility, hydroelectric power will be sold at prices that will render its production unprofitable.

California contains no coal of first quality. What it does contain will not be commercially available until the oil has been largely exhausted and until foreign coals sell at a higher price than now. The United States Geological Survey credits California with a possible billion tons of coal, but no data are at hand for checking this figure. The total amount of coal mined in California to date would approximate the equivalent in fuel value of a three months' production of California oil. When commercially available, it will be affected by low prices of hydroelectric power similar to peat, mentioned above.

Elizabeth Tunnel of the Los Angeles Aqueduct*

THE Los Angeles aqueduct crosses under the crest of the Coast range 45 miles north of the city of Los Angeles. Elizabeth lake is approximately one-half mile east of the centre of the tunnel, and a number of small lakes are situated in the valley westerly from Elizabeth lake. The tunnel is 26,870 ft. long, or 5.09 miles. The Coast range has a double crest at this point, with the valley of the Elizabeth lake almost in the centre of the tunnel line. Where the tunnel crosses this valley, it is 250 ft. beneath the surface of the ground. Work was started by hand at the South Portal October 5, 1907, and at the North Portal, November 1, 1907, and was so prosecuted until adequate machinery could be installed. It was supposed that this long tunnel would be the controlling factor in the time necessary for the completion of the aqueduct. Consequently, equipment of a substantial character was placed here, consisting of four 500-cu. ft. per minute two-stage air-compressors, which afforded duplicate plants at both the north and south ends. One 18-in. positive blower and a track of 36-lb. rails on which electric locomotives were operated were furnished for each portal.

The tunnel was driven on a slope of one foot in a thousand. The timbered section required a theoretical excavation of 5.02 yd. per lineal foot, and the untimbered section 4.18 yd. This is to be a pressure tunnel and is the outlet from the bottom of the Fairmont reservoir. It will be a portion of the penstock of the first power plant south from the crest of the range. The amount of water discharged through the tunnel will vary with the load on the power plants up to 1000 cu. ft. per second, and average 400 cu. ft. per second for the day. The fact that the tunnel diverts from the Fairmont reservoir will permit of this fluctuation. As the electric load factor in Los Angeles is estimated at 40%, the maximum flow of water from the tunnel is two and one-half times the mean. The hydraulic gradient, therefore, will vary with the volume discharged, and will be cared for by the depth of 80 ft. of water over the intake of the tunnel.

The rock in the north half of the tunnel was much broken and consisted mostly of decomposed granite. Much of the ground was very heavy, requiring close timbering, and in numerous places the tunnel had to be retimbered two or three times.

*From the Sixth Annual Report of the Bureau of the Los Angeles Aqueduct, Wm. Mulholland, chief engineer; J. B. Lippincott, assistant chief engineer.

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Large flows of water were encountered and also swelling ground. The excavation of this portion of the tunnel was most difficult, and called for courage, skill, and persistence. At 1117 ft. from the North Portal, a large fissure filled with sand and water was encountered which broke through the face of the tunnel and could not be passed from that side. This caused considerable delay. Therefore a shaft was put down 3000 ft. from the portal, and the heading driven each way therefrom, in order to maintain the progress schedule and to approach the dangerous ground from the south. This running water and sand was finally overcome by driving overlapping steel rails in advance of the heading, and closely following with careful excavation and timbering. John Gray, superintendent for the north end, has accomplished a remarkable work in the driving of this half of the tunnel without further mishap.

The south half of the tunnel was in a gneissoid granite, in some places rather soft and in others hard. Broadly speaking, it was ideal tunnel ground. This portion of the tunnel, as a rule, required no timbering. The south end was in charge of W. C. Aston, tunnel superintendent. In driving the tunnel in hard rock, the full section was drilled and shot, each shift getting in a round and firing it. Where the ground was heavy at the north end, a lower heading was driven in advance, using false sets and crown-bars which carried the weight of the roof ahead of the front set. The tunnel was then widened by putting in the permanent posts, the temporary floor, from which the upper section of the tunnel was excavated, the roof segments being placed as the material was removed, the whole process being one of a carefully detailed advance.

When this tunnel work was started, it was estimated that a reasonable progress for each end would be eight feet per day with three eight-hour shifts, and a bonus schedule was adopted by the Board of Public Works which provided that each man working in the tunnel, up to a limited size shift, would receive a bonus of 40c. for each foot that this schedule was exceeded, the progress to be measured at the end of each 10-day period. This bonus was paid in addition to the regular wages for tunnel work in this section, the men receiving these wages whether the bonus schedule was exceeded or not, and the bonus being distinctly a reward for extra exertion. As the costs for driving the tunnel are quite constant for each day's work, the cost per foot consequently would vary with the rate of progress, and it was estimated that this bonus would be considered as the men's equal share in the saving to the city resulting from the beating of the base rate. From the South Portal, 13,500 ft. of tunnel was driven, and from the North Portal, 13,370 ft. The average rate of progress at the South Portal was 11.11 ft. per day; at the North Portal, after the connection was made through to the shaft, the average progress was 13.65 ft. per day. From the portal to the end of the section driven from the north end, including delays on account of shaft and cave-ins, the average progress was 11 ft. per day. The average progress for the two headings for the 1215 days' work was 22.1 ft., or a little better than 11 ft. per day for each end. The connection was made of the two headings on February 28, 1911, after the expiration of 40 months of work. (The time which the Board of Engineers estimated as necessary to complete this was five years.) The centre line of the tunnel met within 1⅛ in. and the grade checked within ⅝ in. The total cost per foot for the driving of the tunnel, including administration, equipment, surveys, etc., but not lining, was $44.80, and the saving over the estimate of the Board of Engineers was about $500,000.

An interesting incidental feature of this work was that the tunnel was driven as rapidly and as cheaply near the centre as it was near the portals; in other words, the transportation by electric locomotives and the strong ventilating system was adequate to prevent delay. The organization of the work and the experience gained by the engineers rather reduced the unit cost as the work proceeded. While almost the same distance was driven from both portals, the work at the north end was interrupted by excessive flows of water, which had to be pumped out. It is noteworthy that at the south portal of the tunnel, one 18-in. blower was sufficient to quickly ventilate it up to the last thousand feet. Great credit is due to the superintendents at both ends of the tunnel for the records made, both in speed and economy.

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Analytical Control of Water Softening

The methods of water analysis as applied to control of water softening are discussed by Andrew Jacobson in the report for 1909-1910 on the chemical and biological survey of Illinois waters, under direction of Edward Bartow. The purpose of softening water is stated to be to eliminate as far as possible those constituents which make it undesirable for use in boilers and for industrial processes. The undesirable constituents include carbonates, sulphates, chlorides and nitrates of calcium, magnesium, iron, and aluminum. Carbonic acid, free hydrochloric and sulphuric acids are sometimes present and also cause trouble.

Two general types of softening plants are in use at the present time; the intermittent and the continuous. The chemical reactions involved in either type are the same, but the mechanical devices for accomplishing thorough softening and purification vary. The elements necessary to produce a satisfactory soft water are addition of definite quantities of reagents, thorough mixing of reagents with the water to be softened, time necessary to complete the reactions and to allow the precipitate to settle. The simplest form of intermittent softening plant consists of two tanks, each holding as much water as will be consumed while the softening process is in progress in the other tank. Calcium carbonate and magnesium hydroxide settle very slowly in the cold, about 2.5 inches per hour, according to Wanklyn. Some continuous types of softener reduce this time element by reducing the distance which the precipitate has to settle. This is accomplished by superimposed tanks or inclined shelves which catch the pricipitate, and allow the softened water to be drawn off without disturbing tne sludge. For ground waters having a fairly constant quantity of dissolved solids, the required lime addition can be regulated to a high degree of accuracy. With surface waters in which the amount of dissolved material varies widely from time to time this type of softener is not entirely satisfactory. Another method of water softening is to utilize the exhaust steam or flue gases for heating the water to the boiling point before it enters the boiler. At this temperature the bicarbonates are changed to insoluble normal carbonates. Sometimes soda is added to change the chlorides and sulphates of calcium and magnesium to carbonates.

The determination of the amount of reagents to be added to a water may be effected in several ways. A logical method of accomplishing the result would be to treat a series of samples with varying amounts of the reagent and to analyze the filtrate after the completion of the reaction. This method, however, is not practical. The most accurate method is to make a complete mineral analysis. This involves the determination of the ions sodium, ammonium, magnesium, calcium, iron, aluminum, nitrate, chlorine, sulphate, carbonate, and silica. From these ions the amount of reagents to be added may be calculated by the use of proper factors. Herman Stabler has deduced a very ingenious formula, which is given below, for determining from the ions the amount of 90% lime and 95% soda required per 1000 gallons of water treated.

$$\text{Lime required} = 0.26(\text{rFe} + \text{rAl} + \text{rMg} + \text{rH} + \text{rHCO}_3 + 0.0454\ \text{CO}_2)$$

$$\text{Soda ash required} = 0.465(\text{rFe} + \text{rAl} + \text{rCa} + \text{rMg} + \text{rH} - \text{rCO}_3 - \text{rHCO}_3)$$

'r' is a constant for each ion, and is the ratio of the valence to the combining weight of each ion. This formula may be greatly simplified by writing it:

$\text{Lime} = 0.0052(4.16\ \text{Mg} + \text{Alk} + 2.27\ \text{CO}_2^*)$ lb. per 1000 gal. of 90% CaO.

$\text{Soda ash} = 0.0093(4.16\ \text{Mg} + 2.5\ \text{Ca} - \text{Alk})$ lb. per 1000 gal. of 95% Na_2CO_3.

Iron and aluminum are not figured in the above formula because they are generally low. However, if iron is present as a carbonate it is included in alkalinity. HCO_3 and CO_2 are generally determined by titration, the former by means of a standard acid and the latter by a standard sodium carbonate solution. The error, therefore, will be the same in both formulæ. E. G. Bashore calculates the lime required by dividing each grain of calcium and magnesium bicarbonate reported in the analysis as carbonate by 5.5. This is incorrect in principle, because magnesium is not precipitated as a carbonate but

*If CO_2 is reported in parts per million as CaCO_3 the factor is 1.

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as a hydrate. He calculates soda by dividing the number of grains per gallon of magnesium sulphate by 8 and the number of grains of calcium sulphate by 8.75. The quotient represents pounds per 1000 gallons.

In order to show that the same results are obtained by calculating the lime and soda required according to the methods already suggested, an analysis has been calculated according to Stabler's formula, the simplified formula, and hypothetical combinations. The result is as follows:

Ions.		Hypothetical Combinations.	
Na	52.0	NaCl	41.0
Mg	24.3	Na_2SO_4	112.0
Ca	68.8	$MgSO_4$	76.4
Fe	0.2	$MgCO_3$	32.6
Al_2O_3	1.8	$CaCO_3$	167.0
Cl	25.0	$FeCO_3$	0.4
SO_4	137.0	Al_2O_3	1.8
SiO_2	18.7	SiO_2	18.7
			449.9

Stabler's formula:

$$\text{Lime} = 0.26(0.0333 \times 123.6 + 0.0821 \times 24.3) = 1.58$$

Simplified formula:

$$\text{Lime} = 0.0052\ (4.16 \times 24.3 + 206) = 1.58$$

Hypothetical combinations:

$MgSO_4$ ..... $76.5 \times 0.46 = 35.2$
$MgCO_3$ ..... $32.6 \times 1.33 = 43.3$
$CaCO_3$ ..... $167.0 \times 0.56 = 93.5$

Total lime in parts per thousand.....172.0
90% lime per 1000 gal. $0.0092 \times 172 = 1.58$

Stillman[2] has proposed a scheme for the rapid analysis of boiler waters which is an improvement over the complete mineral analysis in that it takes less time. The desired amount of water is evaporated and the residue weighed, thus giving total solids. The residue is then ignited, weighed, moistened with water, placed in an atmosphere of CO_2, and weighed. The last operation gives total mineral matter. The non-scale-forming ingredients are separated from the scale-forming by extraction with 50 c.c. of distilled water, filtered, and the residue treated with HCl. SiO_2, Al_2O_3, Fe_2O_3, Ca, Mg, and SO_4 are determined gravimetrically.

The methods mentioned thus far are accurate, but they have the disadvantage of requiring considerable time. In order to find a rapid, accurate method, the literature on the subject was searched and a number of methods were tried. Each one, however, failed in one or more important details to satisfy the above conditions. The simplest is that credited to Dr. Dudley, former chemist of the Pennsylvania railroad. The residue on evaporation is treated with 70% alcohol; the insoluble residue is called scale-forming. This treatment gives simply the total hardness. It is, however, of value as a substitute for the soap test. A. Elliott Kimberly[3] proposes a method of rapid analysis for water softening. He says: "To calculate the chemicals necessary for the treatment of magnesium water, the following data are necessary: (1) free and half-bound carbonic acid; (2) alkalinity; (3) non-carbonate hardness (incrustants); (4) total magnesium; (5) total calcium; (6) incrusting calcium hardness." Numbers 1, 2, 3, and 4 are determined according to standard methods. Total calcium is calculated by deducting total magnesium (as $CaCO_3$) from total hardness (as $CaCO_3$). Incrusting calcium is determined by concentrating 500 c.c. to 200 c.c., then filtering and determining Ca gravimetrically in the filtrate. An allowance is made for the solubility of normal $CaCO_3$ which is taken as 20 parts per million. From the data thus obtained, the component bases of alkalinity and non-carbonate hardness are calculated. That quantity of calcium present combined with acids other than carbonic is subtracted from the total calcium. The remaining calcium may be assigned to carbonate. The difference between alkalinity determined by titration and that portion due to calcium must be the magnesium component of alkalinity. Calcium is determined directly as described above. The difference between total magnesium and that attributed to alkalinity gives non-carbonate magnesium.

He gives the following data obtained from an analysis by the above scheme, constituents being expressed in parts per million:

		as $CaCO_3$
Alkalinity as $CaCO_3$	252	252
Non-carbonate hardness as $CaCO_3$	174	174
Total magnesium as Mg.....	44	182
Total calcium as Ca.....	98	244
Non-carbonate calcium as Ca.	25	63

[2] 'Engineering Chemistry,' Sec. Ed., p. 53.
[3] *Journal of Infectious Diseases*, Supp. May 1905, p. 157.

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Calculation of lime required to soften above water:

Alkalinity	Ca as $CaCO_3$ ..... 183×0.56 = lime required	= 102
	Mg as $CaCO_3$ ..... 70×1.12 = lime required	= 77
Non-carbonate Mg as $CaCO_3$ ...	112×0.56 = lime required	= 63
	Total lime	242

Calculation of sodium carbonate required to soften the above water:

Non-carbonate	Ca as $CaCO_3$ ..... 62×1.06 = Na_2CO_3 required	= 65
	Mg as $CaCO_3$ ..... 112×1.06 = Na_2CO_3 required	= 119
	Total soda	184

By means of simple formulæ, identical results may be obtained using only a part of Mr. Kimberly's data.

Data required:	Pt. per mil. as $CaCO_3$
Non-carbonate hardness	174
Total Mg	182
Alkalinity	252

Formulæ:

0.56 (Mg + Alk) = lime required.

1.06 × non-carbonate hardness = $NaCO_3$ required.

From a consideration of the above, it is obvious that the determination of total calcium and incrusting calcium is superfluous. It does not throw any additional light on the character of the water. Other methods are reviewed and from them a combination of simple tests is built up that permits determination of the common constituents and calculation of treatment in about one hour. The report includes numerous illustrative calculations and analyses, and concludes with a brief bibliography of the subject.

Methods for Testing Cement*

CEMENT in barrels shall be sampled through a hole made in the head, or in one of the staves midway between the heads, by means of an auger or a sampling iron similar to that used by sugar inspectors; if in bags, the sample shall be taken from surface to centre. Cement in bins shall be sampled in such a manner as to represent fairly the contents of the bin. The number of samples taken shall be as directed by the engineer, who will determine whether the samples shall be tested separately or mixed. The samples shall be passed through a sieve having 20 meshes per linear inch, in order to break up lumps and remove foreign material.

Chemical Analysis.—The metnod to be followed shall be that proposed by the 'Committee on Uniformity in the Analysis of Materials for the Portland Cement Industry,' reported in the *Journal* of the Society for Chemical Industry, Vol. 21, p. 12, 1902, and published in *Engineering News*, Vol. 50, p. 60, 1903, and in *Engineering Record*, Vol. 48, p. 49, 1903, and in addition thereto the following. The insoluble residue shall be determined as follows: To a 1-gm. sample of the cement shall be added 30 c.c. of water and 10 c.c. of concentrated hydrochloric acid, and then warmed until the effervescence ceases, and digested on a steam bath until dissolved. The residue is filtered, washed with hot water, and the filter paper and contents digested on the steam bath in a 5% solution of sodium carbonate. This residue is filtered, washed with hot water, then with hot hydrochloric acid, and finally with hot water, and then ignited at a red heat and weighed. The quantity so obtained is the insoluble residue.

Specific Gravity.—The determination of specific gravity shall be made with a standardized Le Chatelier apparatus. This consists of a flask of about 120-c.c. capacity, the neck of which is about 20 cm. long; in the middle of this neck is a bulb, above and below which are two marks; the volume between these two marks is 20 c.c. The neck has a diameter of about 9 m.m., and is graduated into tenths of cubic centimetres above

*Accompanying Final Report of Special Committee on Uniform Tests of Cement, of the American Society of Civil Engineers, dated January 17, 1912.

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the mark. Benzine (62° Beaumé naphtha) or kerosene free from water shall be used in making the determination. The flask is filled with either of these liquids to the lower mark and 64 gm. of cement, cooled to the temperature of the liquid, is slowly introduced through the funnel (the stem of which should be long enough to extend into the flask to the top of the bulb), taking care that the cement does not adhere to the sides of the flask, and that the funnel does not touch the liquid. After all the cement is introduced, the level of the liquid will rise to some division of the graduated neck; this reading, plus 20 c.c., is the volume displaced by 64 gm. of the cement. The specific gravity is obtained from the formula,

$$\text{Specific gravity} = \frac{\text{Weight of cement, in gm.}}{\text{Displaced volume, in c.c.}}$$

The flask, during the operation, is kept immersed in water in a jar, in order to avoid variations in the temperature of the liquid in the flask, which should not exceed ½°C. The results of repeated tests should agree within 0.01. The determination of specific gravity shall be made on the cement as received; if it should fall below 3.10, a second determination shall be made after igniting the sample at a low red heat. The ignition shall be carried out in the following manner. One-half gram of cement is heated in a weighed platinum crucible, with cover, for 5 minutes with a bunsen burner (starting with a low flame and gradually increasing to its full height) and then heated for 15 minutes with a blast-lamp; the difference between the weight after cooling and the original weight is the loss on ignition. The temperature should not exceed 900°C., and the ignition should preferably be made in a muffle.

Fineness.—The fineness shall be determined by weighing the residue retained on No. 100 and No. 200 sieves. The sieves shall be of brass wire, and shall conform to the following requirements:

No. of sieve.	Diam. of wire. Inches.	Meshes, per lin. in. Warp.	Woof.
100	0.0042 to 0.0048	93 to 101	93 to 103
200	0.0021 to 0.0023	192 to 203	190 to 205

The meshes in any smaller space, down to 0.25 in., shall be proportional in number. Fifty grams of cement, dried at a temperature of 100°C. (212°F.), shall be placed on the No. 200 sieve, which, with pan and cover attached, is held in one hand in a slightly inclined position, and moved forward and backward about 200 times per minute, at the same time striking the side gently, on the up stroke, against the palm of the other hand. The operation is continued until not more than 0.05 gm. will pass through in one minute. The residue is weighed, then placed on the No. 100 sieve, and the operation repeated. The work may be expedited by placing in the sieve a few large steel shot, which should be removed before the final one minute of sieving. The sieves should be thoroughly dry and clean.

Normal Consistence.—The amount of water, expressed in percentage by weight of the dry cement, required to produce a paste[1] of the plasticity desired, termed 'normal consistence,' shall be determined with the Vicat apparatus. In making the determination of normal consistence, the same quantity of cement as will be used subsequently for each batch in making the test pieces, but not less than 500 gm., together with a measured amount of water, is kneaded into a paste, and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other, maintained about 6 in. apart; the ball resting in the palm of one hand is pressed into the larger end of the rubber ring held in the other hand, completely filling the ring with paste; the excess at the larger end is then removed by a single movement of the palm of the hand; the ring is then placed on its larger end on a glass plate and the excess paste at the smaller end is sliced off at the top of the ring by a single oblique stroke of a trowel held at a slight angle with the top of the ring. During these operations care must be taken not to compress the paste. The paste confined in the ring, resting on the plate, is placed under the rod, the larger end of which is carefully brought in contact with the surface of the paste; the scale is then read, and the rod quickly released. The paste is of normal consistence when the cylinder settles to a point 10 mm. below the original surface in one-half minute after being released. The apparatus must be free from all vibrations during the test. Trial

[1]The term 'paste' is used in these specifications to designate a mixture of cement and water, and the word 'mortar' to designate a mixture of cement, sand, and water.

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pastes are made with varying percentages of water until the normal consistence is attained. Having determined the percentage of water required to produce a paste of a normal consistence, the percentage required for a mortar containing, by weight, one part of cement to three parts of standard Ottawa sand, shall be obtained from the following table, the amount being a percentage of the combined weight of the cement and sand.

PERCENTAGE OF WATER FOR STANDARD MORTARS

Neat	1 cement, 3 standard Ottawa sand	Neat	1 cement, 3 standard Ottawa sand	Neat	1 cement, 3 standard Ottawa sand
15	8.0	23	9.3	31	10.7
16	8.2	24	9.5	32	10.8
17	8.3	25	9.7	33	11.0
18	8.5	26	9.8	34	11.2
19	8.7	27	10.0	35	11.3
20	8.8	28	10.2	36	11.5
21	9.0	29	10.3	37	11.7
22	9.2	30	10.5	38	11.8

Time of Setting.—The time of setting shall be determined with the Vicat apparatus in the following manner: A paste of normal consistence is molded in the hard-rubber ring, as described, and placed under the rod, the smaller end of which is then carefully brought in contact with the surface of the paste, and the rod quickly released. The cement is considered to have acquired its initial set when the needle ceases to pass a point 5 mm. above the glass plate; and the final set, when the needle does not sink visibly into the paste. The test pieces must be kept in moist air during the test.

Standard Sand.—The sand shall be natural sand from Ottawa, Illinois, screened to pass a No. 20 sieve, and retained on a No. 30 sieve. The sieves shall be of at least 8 in. diameter, and the wire cloth shall be of brass wire and shall conform to the following requirements:

No. of sieve.	Diam. of wire. Inches.	Meshes, per lin. in. Warp.	Woof.
20	0.016 to 0.017	19.5 to 20.5	19.0 to 21.0
30	0.011 to 0.012	29.5 to 30.5	28.5 to 31.5

Sand which has passed the No. 20 sieve is standard when not more than 5 gm. passes the No. 30 sieve in one minute of continuous sifting of a 500-gm. sample.[2]

Form of Test Pieces.—For tensile tests the form of test pieces prescribed by the Society shall be used. For compressive tests, 2-in. cubes shall be used.

Mixing and Molding.—The material shall be weighed, placed on a non-absorbent surface, thoroughly mixed dry if sand be used, and a crater formed in the centre into which the proper percentage of clean water shall be poured; the material on the outer edge shall be turned into the centre by the aid of a trowel. As soon as the water has been absorbed, the operation of mixing shall be completed by vigorous kneading with the hands for one minute. Immediately after mixing, the paste or mortar shall be placed in the mold with the hands, pressed in firmly with the fingers, and smoothed off with a trowel without ramming. The material shall be heaped above the mold, and, in smoothing off, the trowel shall be drawn over the mold in such a manner as to exert a moderate pressure on the material; the mold shall then be turned over and the operation of heaping and smoothing off repeated. The temperature of the room and of the mixing water shall be maintained as nearly as practicable at 21°C. (70°F.).

Storage of the Test Pieces.—During the first 24 hours after molding, the test pieces shall be stored in a moist closet. This consists of a box of soapstone or slate, or of wood lined with metal, the interior surface being kept covered with felt or broad wicking kept wet, the bottom of the box being kept covered with water. The interior of the box is provided with glass shelves on which to place the test pieces, the shelves being so arranged that they may be withdrawn readily. Test pieces from any sample which vary more than 3% in weight from the average, after removal from the moist closet, shall not be considered in determining strength. After 24 hours in the moist closet, the pieces to be tested after longer periods shall be immersed in water in storage tanks or pans made of non-corrodible material. The air and water in the moist closet and the water in the storage tanks shall be maintained, as nearly as practicable, at 21°C. (70°F.)

[2]This sand may now (1912) be obtained from Ottawa Silica Co., at a cost of 2c. per pound, f. o. b. cars, Ottawa, Illinois.

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Tests of Tensile Strength.—The tests may be made with any standard machine. The clip is of form as specified with roller edges. It must be made accurately, the pins and rollers turned, and the rollers bored slightly larger than the pins so as to turn easily. There should be a slight clearance at each end of the roller, and the pins should be kept properly lubricated and free from grit. The clips shall be used without cushioning at the point of contact. The test pieces shall be broken as soon as they are removed from the water. The load shall be applied at the rate of 600 lb. per minute. Test pieces which do not break within ¼ in. of the centre, or are otherwise manifestly faulty, shall be excluded in determining average results.

Tests of Compressive Strength.—The tests may be made with any machine provided with means for so applying the load that the line of pressure is along the axis of the test piece. The test pieces as soon as they are removed from the water shall be placed in the testing machine, with a piece of heavy blotting paper on each of the crushing faces, which should be those that were in contact with the mold.

Constancy of Volume.—The tests for constancy of volume comprise 'normal tests,' which are made in air or water maintained as nearly as practicable at 21°C. (70°F.), and the 'accelerated test,' which is made in steam.

These tests shall be made in the following manner: Pats about 3 inches in diameter, ½ in. thick at the centre, and tapering to a thin edge, shall be made on clean glass plates about 4 in. square, from cement paste of normal consistence, and stored in a moist closet for 24 hours. In the case of *normal tests*, after 24 hours in the moist closet, a pat is immersed in water and observed at intervals. A similar pat after 24 hours in the moist closet is exposed to the air for 28 days or more and observed at intervals. The air and water are maintained as nearly as practicable at 21°C. (70°F.) In case of *accelerated tests*, after 24 hours in the moist closet, a pat is placed in an atmosphere of steam, upon a wire screen 1 in. above boiling water, for 5 hours, the apparatus being such that the steam will escape freely and atmospheric pressure be maintained. The cement passes these tests when the pats remain firm and hard, with no signs of cracking, distortion, or disintegration.

Proposed Federal Department of Public Works

NEED of closer coöperation between the various Bureaus at Washington that are concerned with engineering work was emphasized by C. E. Grunsky in his address as president of the San Francisco chapter of the American Society of Civil Engineers, February 16. This matter has been frequently discussed, but no plan of reorganizing the Government work has yet received the support necessary to its adoption. Mr. F. G. Newlands introduced a bill into the Senate designed to cure the evils of which complaint is made.

Mr. Grunsky urges strongly that the most economical solution of the difficulty will be found in the organization of a Department of Public Works. He calls attention to the fact that before Major J. W. Powell, of the U. S. Geological Survey, had the matter of stream measurement taken up by that Bureau, no systematic studies of these resources were being made. The work inaugurated by him and continued under his successors, C. D. Walcott and G. O. Smith, he says, has borne great fruit. The engineers throughout the width and breadth of the land have constant occasion to refer to the results of these studies, many of which were made under coöperation with the individual states. And yet these studies are not as broad and extensive as they ought to be. They should be conducted on a much larger scale. The work done by the Water Resources Branch of the Geological Survey is, nevertheless, of permanent value. The engineer, whose problem relates to the utilization of run-off waters, or to the protection of lands against inundation, or to the improvement of river channels, searches the records as far back as they go and wishes for more. He is bound to do this. He cannot at a moment's notice go afield

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and gather adequate reliable facts by an examination of the stream. Nature does not put the stream either into its extreme low stage nor yet into its maximum flood stage just to accommodate the engineer who wants knowledge of these extreme conditions. For such information the records supplied by the U. S. Geological Survey are invaluable. A stream may be in maximum flood only once in a century. Shall the engineer conjecture what this may be, or will the nation make and maintain adequate provision to gather such data and have them ready and easily accessible when they are required? Such questions as this prompted the U. S. Geological Survey, under able leadership, to take up and to continue the work of measuring streams. And yet almost annually there is an attempt made in Congress to curtail, or to cut out altogether, the already inadequate annual allowance of some $150,000 or $200,000 for the work. And the question is asked, and with some reason, too: 'What has the Geological Survey to do with stream gauging?' This Bureau, under the Secretary of the Interior, has had the wisdom to recognize the importance of this work and has had the courage to take it up because there was no one else to do it, because there was no properly organized department of public works in our scheme of government. The Geological Survey deserves full credit for its foresight and should receive every needed assistance, so long as this work remains in its charge. When in 1902 the act for the reclamation of arid and semi-arid lands by irrigation was passed by Congress, it was natural to place this reclamation work in charge of the men whose preliminary studies and investigations had led up to the passage of the act. The hydrographers of the U. S. Geological Survey became the engineers of the U. S. Reclamation Service, and within a few years a new bureau was created with a director at its head, and this has been in charge of great irrigation works on which upward of $60,000,000 has already been expended.

When in 1903 the question of how to handle the work of constructing an interoceanic canal came up for consideration in Congress, it was resolved to create a Commission, the majority of whose members were to be engineers. The Commission, according to the law, was placed directly under the President, but the President determined that it would be convenient to deal with the Commission through one of his Cabinet Officers, and selected the Secretary of War. The Department of Agriculture is making studies of swamp-land reclamation and maintains a corps of engineers, which may before long be placed in charge of drainage works on a large scale. The U. S. Coast and Geodetic Survey conducts its work in aid of navigation under the Secretary of Commerce and Labor. The public buildings of the country are planned and erected under the Secretary of the Treasury, who maintains an architectural bureau, with a Supervising Architect at its head. The river and harbor improvements and all aids to navigation are in charge of the Engineer Corps of the U. S. Army, which comes the nearest to performing the functions of a bureau of public works, but which has never looked upon the related problems in the broad progressive way that led the U. S. Geological Survey into a study of stream flow.

What is now needed is a Department of Public Works with a member of the Cabinet at its head, which shall be in complete charge of all of these bureaus; which shall have charge, in fact, of all public works and related matters. There is no reason why a Secretary of Public Works at the head of such a department should not replace one of the Secretaries of whom the Cabinet is now composed. Such a reorganization could readily be effected. The nucleus for the engineering staff of such a department would naturally be the Engineer Corps of the U. S. Army; but, under proper restrictions, there should also be admitted, on an equal footing with West Point graduates, the graduates from our other engineering schools of recognized standing, the sole distinction between the military and the civilian engineer being in the matter of assignment to military duty and to problems directly related to our defenses and other military matters. Under such a department the study of our resources, the surveys and stream measurements, river and harbor improvements, canal works, public buildings, land reclamation by irrigation and by protection against inundation, and all that goes with such works, would receive a permanency of direction and purpose that cannot otherwise be hoped for.

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Flood Control in the Sacramento Valley

THE problem of flood control in the Sacramento Valley region has been of yearly recurrence and the subject of much investigation by engineers during the last 25 years. The financial phase of the problem has proved a stumbling block in the way of putting into execution any of the methods as yet advocated, since the enormous expense involved would place a burden of taxation upon the people of California such as makes the Legislature hesitate before submitting it to the people. At last, however, a plan covering both the financial and engineering phases in such a way as to bring the whole project within the bounds of possibility has been drawn up and submitted to Congress by the California Débris Commission. It is now before the House Committee on Rivers and Harbors. The report is dated June 29, 1911, signed by Lieut.-Col. John Biddell as senior member of the California Débris Commission, Capt. Thos. A. Jackson, and First Lieut. Chas. T. Leeds.

The method of flood control recommended is known as the 'by-pass' system, advocated by Messrs. C. E. Grunsky and Marsden Manson in their report made as consulting engineers to the Commissioners of Public Works in 1894. It stands in contrast to the 'main channel' system advocated first by William Ham Hall, state engineer, and his associates in 1880, and again by the Dabney Commission, consisting of Messrs. T. G. Dabney, Henry B. Richardson, M. A. Nurse, and Maj. H. M. Chittenden, in 1904. The employment of the by-pass system will involve: (1) the enlargement and utilization of the river channels to their maximum capacity as drainways, that is, channel rectification; (2) permitting the overflow of surplus waters from the river channels at stated points; (3) control of surplus waters between embankments forming by-pass channels, and a rapid delivery of the same into Suisun bay. The Commission believes that this principle will accomplish the desired result without injury to Suisun bay or interference with navigation in Sacramento river from Cache slough to Colusa. The following work is recommended: (*a*) dredging to flood channel section that portion of the river below Cache slough, with rectification of the channel by a cut-off at Horseshoe bend; (*b*) improving the channel at various points, especially at the head of Steamboat slough, so that the river from Cache slough to American river will have a capacity of about 100,000 cu. ft. per second. (*c*) constructing a weir opposite the mouth of Feather river and connecting it by means of a permanent by-pass in Yolo basin with Cache slough, this by-pass and weir to be of sufficient cross-section to carry all flood waters that cannot be carried by the present river below the above weir; (*d*) constructing a weir at Moultons break, about 13 miles above Colusa, and connecting it by means of a permanent by-pass in the Sutter and Butte basins, with the Sacramento river at its junction with Feather river, this weir and by-pass to be of sufficient capacity to carry all flood waters that cannot be carried by the present river below this weir; (*e*) increasing the cross-section of the river above Moultons break by raising the levees and placing them farther apart, so that the increased cross-section will provide for the estimated discharge; (*f*) constructing a weir at Brytes bend, two miles above the mouth of the American river, and connecting it by means of a permanent by-pass with the Yolo basin by-pass, this by-pass and weir to have a capacity of about 70,000 cu. ft. per second, or sufficient to carry the excess flood water that reaches that point; (*g*) reconstructing the present Tisdale weir and connecting it by means of a permanent by-pass with the Sutter-Butte by-pass, the weir and by-pass to have a capacity of about 35,000 cu. ft. per second, or sufficient to carry the excess flood water that reaches that point; (*h*) confining to their present channels by means of levees the flood waters of all of the important tributary streams; (*i*) collecting the hill drainage in intercepting canals and conveying it to the rivers or by-passes at convenient points; (*j*) providing for the drainage of the basins by placing culverts with gates at various points in the by-pass levees.

This method of control possesses many advantages as compared to a main channel project, including: (1) low first cost ($33,000,000, estimated, being only about 35% of that of a main channel project); (2) lower maintenance costs, both from a standpoint of

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navigation and flood control; (3) no injury to Suisun bay by the scouring of hundreds of millions of yards of material into it; (4) a shorter construction period; (5) the adaptability of the by-pass system for use as storage reservoirs for power or navigation purposes.

The quantity of water to be handled varies with the season's rainfall, and, in the event of the season being excessively dry, the by-passes might not be called into use at all, but as it is considered that the flood of 1907 marked an unprecedented condition. It is proposed to provide for a possible repetition of these conditions as a maximum, the run-off during March 18 to 21, inclusive, averaging 554,700 cu. ft. per second from a drainage area of 27,126 square miles. These figures are taken from the U. S. Geological Survey records and are based upon an assumption of 50% of the precipitation in the case of the mountains and foothills, and 43% for the Sacramento valley proper. The total estimated cost of the project, exclusive of any provision for maintenance, is $33,000,000, segregated as follows:

Levees:		
58,000,000 cu. yd. at 6 cents	$3,480,000	
28,000,000 " " " 12 "	3,360,000	
18,000,000 " " " 20 "	3,600,000	
		$10,440,000
Excavation:		
148,000,000 cu. yd. at 6½ cents	$9,659,000	
8,250,000 " " " 12½ "	1,031,250	
380,000 " " " 25 "	95,000	
		$10,785,250
Land:		
4,400 acres at $200	$880,000	
8,400 " " 75	630,000	
78,000 " " 25	1,950,000	
		3,460,000
Spillways:		
8,000 feet at $125	$1,000,000	
4,500 " " 100	450,000	
1,140 " " 80	91,200	
		1,541,200
Bridges		1,382,000
Miscellaneous		1,740,000
Engineering and contingencies, 15%		4,451,550
Total		$33,800,000
Less amount appropriated under existing project		800,000
Total		$33,000,000

The gain to the state of California from the reclamation and prevention of damage to reclaimed lands would be enormous, but the United States would also gain by keeping the present channels uninjured. It is the opinion of the Commission that both should therefore share in the construction of the works under this project, the United States to the extent of 33⅓%. It is also the opinion of the Commission that the state of California will benefit to such an extent by the control of the floods of the river that upon the completion of this project it should take over and maintain all flood-control works, the United States providing only for the maintenance of navigable channels. The specific recommendations of the Commission are:

1. That the United States begin at once the work for the control of the floods of the Sacramento river in accordance with the above project and provide for its early completion.

2. That the United States contribute one-third of the cost of work and the state of California the remaining two-thirds.

3. That upon its completion the United States turn over to the state of California for maintenance at the state's expense, all flood-control works.

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Book Reviews

ECONOMICS OF CONTRACTING. By Daniel J. Hauer. Pp. 269. E. H. Baumgartner, Monadnock Bdg., Chicago, 1912. For sale by the *Mining and Scientific Press*, San Francisco, California. Price $2.50.

This book fills a void in the literature of general contracting, for while all works on this subject deal with the economic feature to a greater or less extent, none cover this essential phase of contracting so thoroughly. Mr. Hauer is the Eastern editor of *The Contractor* and has had an experience of over 20 years in the actual practice of his profession. His thorough understanding of the subject becomes more and more apparent with the perusal of each successive page, and he is to be congratulated upon grouping the various captions in the order in which they would naturally occur in the actual handling of a contract.

The book is divided into ten sections with addenda, covering contracting as a profession, form of contracts, proposals, bonds, arbitration, and other features of contracts, the business and clerical ends of contracting, contractors' workmen, construction camps, management of contracts, contractors' outfit and plans, and a chapter covering various legal problems, employers' liability, etc. Mr. Hauer rightfully classes contracting as a profession, and this is especially true in the case of the engineering contractor, who differs in the practice of his profession from the consulting engineer in that he must pay for his own mistakes. Proper emphasis is placed upon the importance of foresight, especially in the smaller details, which, trivial as they seem at first, have so much bearing upon the successful completion of the contract, and especially upon the costs. Chapters seven and eight go into these questions at some length and teach lessons of value even to the contractor of long experience. The proper selection of a site for a camp and the essentials that a suitable camp-site should possess are matters that are understood by the experienced contractor, but are often neglected in the press of other matters, with the result that he has to pay heavily in increased cost and delays that might have been avoided had due diligence and care been exercised in the first place. Lack of space prevents the discussion of all the salient features of this book, and in fact it would be difficult to differentiate in favor of any one of the subjects into which the general title is divided. This book will be a valuable addition to the library of anyone interested in the subject, whether he be student, contractor, or teacher.

APPLIED METHODS OF SCIENTIFIC MANAGEMENT. By Frederic A. Parkhurst. Pp. 314, index, 39 illustrations. John Wiley & Sons, New York, publishers. For sale by the *Mining and Scientific Press*, San Francisco, California. Price $2.

As stated in the preface, this work is an amplification of the author's articles published in *Industrial Engineering* during 1911 and is based primarily upon the experience and results obtained by the organization of the Ferracute Machine Co., makers of presses and dies at Bridgeton, New Jersey. The application of scientific management in this particular instance is an excellent example of what may be accomplished in the way of improved factory organization when the product manufactured is comparatively homogeneous in its character. Each section of the company organization is treated individually and its functions specifically and clearly defined in order to prevent the frequent encroachment of one department upon the duties of another, which is one of the most glaring faults of the old-time systems (if they may be so called). The importance of standardizing shop methods and tools is rightfully emphasized. The tabulated labor cost comparisons of the old and new methods make a striking exhibit of the thorough practicability of scientific management, showing in many cases a saving of from 50 to 80%, while wages, on the other hand, increased from 15.9c. per hour to 26.7c. per hour, and the average working day reduced to 8.2 hours. The various forms, blanks, and memoranda used for shop purposes and interdepartment communication are illustrated in full and their use and application described at length.

While we do not know of an instance where an attempt has been made to apply the principles of scientific management to a manufacturing plant turning out a heterogeneous product or engaged in a general jobbing business, we know of no reason why the fundamental principles involved should not ultimately find a ready applica-

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tion to any set of conditions when labor is employed in the fabrication of material. Mr. Parkhurst rightfully emphasizes the fact that each specific case must be the subject of individual study and attention and that no set rules could possibly be laid down that would be applicable to each case, but a thorough understanding of principles involved may be acquired through study of the results attained by experts, and the manufacturer can then either work out his own salvation—or, better, secure the services of a specialist who has been successful in the introduction of scientific management elsewhere.

BUREAU OF THE LOS ANGELES AQUEDUCT, SIXTH ANNUAL REPORT. Wm. Mullholland, Chief Engineer; J. B. Lippincott, Assistant Chief Engineer. Pp. 72. Ill. Los Angeles, 1911.

An extensive extract, relating to the Elizabeth tunnel, is given this month in THE ENGINEERING DIGEST. It may serve as an example of the interesting data with which this report is replete, at the same time that it gives an idea of the high class of work being done on the aqueduct. As to the progress of the work, the report gives the following figures: "On the aqueduct proper, exclusive of the power conduit in the San Francisquito canyon, there has been excavated up to the close of the fiscal year, 41 out of the total 42.9 miles of tunnel, of which 25 miles have been lined with concrete; of the covered conduit, 72 out of the total 97.69 miles have been excavated, and 63 miles have been lined; of the 37.2 miles of uncovered conduit, 15 miles have been excavated and 14 miles have been lined; of the 23.3 miles of open and unlined canal, 17 miles have been excavated; of the 12.43 miles of siphon, one mile has been built. On the assumption that five years' time is required for the construction of the aqueduct, beginning at the time the Elizabeth tunnel was started in October 1907, 75% of the time has elapsed. While the work on the Elizabeth tunnel was begun on this date, general construction work did not start until October 1908, and assuming that four years' time will be required from October 1908, 69% of the time has elapsed. Of the entire amount of lineal feet of aqueduct excavation, 68½% has been done, and 60½% of lining has been placed."

ILLINOIS HIGHWAY COMMISSION, A. N. Johnson, State Engineer. THIRD REPORT, 1908-1909. Pp. 156. Ill. Springfield, Illinois, 1911.

The report of this active and efficient Commission contains much that is of general interest to engineers. We print elsewhere details regarding the design of small concrete bridges, with which the engineers of the Illinois Commission have had an unusual amount of experience.

UNITED STATES RECLAMATION SERVICE. F. H. Newell, Director. TENTH ANNUAL REPORT, 1910-1911. Pp. 260. Washington, 1912.

The tenth report of this great Service follows the lines of those of past years. The progress of work on each project is briefly reviewed and full statements as to costs are given. Indeed, for engineers outside the Service the greatest element of value in this report is cost data, though there are also tabulations of cement tests and other material of large usefulness. The report is too detailed to permit of review, but notes on individual projects will be printed from time to time.

CHEMICAL AND BIOLOGICAL SURVEY OF THE WATERS OF ILLINOIS. Edward Bartow, Director. Rept. 1909-1910. Pp. 148. Ill.; index. Urbana, Illinois, 1911.

This bulletin forms No. 8 of the series issued by the State Water Survey and contains a large amount of most useful matter bearing on water-supplies. Industrial chapters are devoted to the Lake Michigan Water Commission; the Illinois Water Supply Association; Composition and Treatment of Lake Michigan Water; Action of Bleaching Powder in Water Purification; Treatment of Water in Boiler Compounds; Relation of Typhoid Fever to the Water Supplies of Illinois; Analytical Control of Water Softening (noticed in THE ENGINEERING DIGEST this month); Nitrite Destruction Test for a Polluted Water; A Convenient Camera for Color Comparisons in Nessler Tubes; Additional Farm Water Supplies; A Water Works Laboratory; and Suggested Disposal of Drainage at Toronto. The bulletin affords an example of the material that may be properly published by a state organization devoted to educating the public to an intelligent interest in water problems.

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Engineering Bonds

*Tax exempt in California.
†Legal investment for savings banks in California.
‡Available as security for deposit of state, county, and municipal funds and postal savings deposits.

*‡The water bond issue of the city and county of San Francisco is dated July 1, 1910, due July 1, 1923-53, and is issued in denominations of $1000, bearing interest at 4½%. The assessed valuation in 1911 was $545,405,664; the total bonded indebtedness $21,276,100, of which $1,425,000 represents the water debt, having a net total of $19,851,100.

*‡Glenn county, California, has issued road and bridge 5% bonds, dated November 1, 1911, and due November 1, 1921-50, inclusive, in denominations of $1000, bearing interest at 5%; total amount, $450,000. The total assessed valuation in 1911 was $14,174,441, and the total bonded indebtedness, including this issue, $457,000. The estimated population is 10,000.

*‡The state of California has issued harbor improvement sinking fund bonds dated July 2, 1911, and due July 2, 1985, in denominations of $1000, with interest at 4%, total amount authorized $9,000,000. Highway bonds have also been issued, dated July 3, 1911, and due July 3, 1917, with interest at 4%, in denominations of $1000; total amount authorized $18,000,000. The assessed valuation of the state in 1911 was $2,603,296,264, and the outstanding bonded debt $4,000,000.

*‡The bond issue of the city of Los Angeles, California, for water works, is dated December 1, 1907, maturing December 1, 1914-47, inclusive. Denominations are $1000, interest 4%. The assessed valuation 1911-12 is $383,078,890, the total bonded debt being $24,160,787.50, of which amount the water debt is $21,296,150; leaving a net debt of $2,864,637.50. Population 1910 was 319,198, being an increase over 1900 of 211.5%. It is estimated that the Los Angeles aqueduct will be completed in February 1913, and that it will afford sufficient water to supply a population of 2,000,000. Progress of this work is reviewed on another page.

*†The San Francisco, Napa & Calistoga railway has issued first mortgage gold bonds dated November 21, 1911, and due December 1, 1936, in denominations of $1000, $500, and $100, the total amount authorized being $1,000,000, of which $600,000 is being issued. The company has acquired all of the property of the San Francisco, Vallejo & Napa railroad and the Vallejo, Benicia & Napa Valley railroad and is operating 33.39 miles of single-phase electric railway between St. Helena in Napa county and Vallejo in Solano county, California. The surplus over and above annual interest charge on bonds for the years 1908, 1909, 1910, and 1911, was $10,683, $21,387, $31,275, and $35,395, respectively.

*†The Pacific Light & Power Corporation of Los Angeles has authorized $35,000,000 in first and refunding mortgage 5% sinking fund gold bonds, dated September 1, 1911, and due September 1, 1951, the amount of the present issue being $10,000,000, in denominations of $1000 and multiples. The present development includes 55,000 hp. in steam generating plants, 20,000 hp. in hydroelectric generating plants, and 450 miles of transmission lines. For the year 1911 the gross earnings of the company amounted to $2,255,000; operating expenses and taxes were $1,224,000, net earnings $1,031,000, other income $37,500; available for fixed charges, $1,068,500. Bonds and other interests required $468,500, leaving a surplus above interest charges of $600,000. There is a report on new development by the Stone & Webster Corporation, Boston.

*†The Pacific Gas & Electric Co. of San Francisco has issued general and refunding mortgage 5% gold bonds amounting to $20,000,000, dated December 1, 1911, and due January 1, 1942, in denominations of $1000. This company owns all of the properties formerly belonging to the California Gas & Electric Corporation, the San Francisco Gas & Electric Corporation, and many other companies engaged in the manufacture and sale of gas and electricity for lighting, heat, and power. The gross earnings for 1911 were $14,682,669; operating expenses, maintenance, and taxes $8,151,364; net earnings, $6,531,305; bond interest, $3,278,177; balance, $3,253,128. Physical valuation of property by J. G. White & Co., engineers.

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Engineering News

Streets and Roads

Sanger.—A campaign for good roads is to be commenced by the Fresno County Chamber of Commerce and a bond issue of $3,000,000 will be advocated.

Sacramento.—Sacramento county is considering the construction of a new road between Sacramento and a point opposite Antioch to cost $100,000.

San Francisco.—N. W. Halsey & Co. were the successful bidders for the $250,000 issue of highway bonds for San Joaquin county, California.

San Jose.—Commercial and civic bodies of Santa Clara county have adopted resolutions asking the Board of Supervisors to pass laws providing for the institution of a County Highway Commission and have asked for a special bond election to provide for an issue of $1,000,000 for road construction.

San Leandro.—The Chamber of Commerce has adopted resolutions asking the Board of Supervisors of Contra Costa county to extend the Moraga Valley road from San Leandro into Contra Costa county.

Power, Gas, and Electricity

San Francisco.—The Pacific Gas & Electric Co. will construct a new concrete warehouse on G street between Fresno and Mariposa. This company has declared a dividend of $1.25 per share on all outstanding common stock, which is $30,000,000.—The Coast Counties Gas & Electric Co. has been incorporated with capital stock $4,000,000. The incorporators are Henry Mallock, Oakland; Wm. R. Bosley, San Francisco; Geo. H. Sussman, S. W. Pryor, S. Volmer, K. L. Dazey, San Francisco, and J. E. Daub, Oakland.—The Coast Valleys Gas & Electric Co. has been incorporated by H. A. Thornton, Berkeley; John F. Forbes, Alameda; F. W. Geiger, San Francisco; A. R. Franklin, Sausalito; G. V. Matthews, San Francisco; with capital stock, $5,000,000.—The Universal Electric & Gas Co. has purchased a power-plant site, 275 by 275 ft., at First and Brannan streets, where a 40,000-kw. electric generating plant will be built.—The San Francisco Oakland Terminal Power Co. has been incorporated by F. O. Harrington, L. L. Dunn, Lloyd L. Jackson, L. Abbot, Nat Schmulowitz, and C. Cosner, with capital stock, $30,000,000.—The San Francisco Oakland Terminal Railways has also been incorporated and a $30,000,000 bond issue projected. The two companies are said to have been formed for the purpose of consolidating all of the Smith-Tevis-Hanford interests, including the Oakland Traction Co., Key Route system, California Railways, and East Shore & Suburban Railway.—The Mount Shasta Power Corporation has been incorporated by Charles L. Firebaugh, Joseph Haber, Jr., Alexander M. Moore, and Edgar Sinsheimer, with a capital stock of $10,000,000. The power plant is in Shasta county.—The following mortgages have been filed to secure bond issues: Feather River Power & Irrigation Co., S. A. Moss, president, A. E. Boynton, secretary, $10,000,000; Oro Water, Light & Power Co., J. W. Goodman, president, W. G. Jack, secretary, $10,000,000; California-Oregon Power Co., J. W. Churchill, president, A. J. Rosborough, secretary, $10,000,000.

Oakland.—The National Power Co. has been incorporated by Leon M. Gove, H. L. Breed, Charles Gross, J. E. Bowes, and E. A. Hermann, with capital stock, $10,000,000.—A decision has been rendered by Judge M. M. Sayre of the Superior Court of Contra Costa county giving the Great Western Power Co. the right to sell light and power in the city of Martinez.

Los Angeles.—Fourteen hundred men are employed on the Big Creek project of the Pacific Light & Power Co. A railroad to cost $1,000,000, leaving the S. P. lines at Gordon switch between Clovis and Friant, and following the lines of the San Joaquin river to the junction of Big creek and thence to the Basin, will soon be under construction. The storage dam capacity will be 80,000 acre-feet and the head 1850 ft. The transmission line will extend from Big creek to Los Angeles. Stone & Webster are the engineers.

Vallejo.—The Great Western Power Co. is preparing to extend its service into Solano county and is seeking a franchise from the Board of Supervisors.

Antioch.—The Contra Costa County Gas Co. has secured franchises from Antioch, Pittsburg, and Martinez, and the work of laying mains will commence about April 1.

Placerville.—The Western States Gas & Electric Co. will expend approximately $100,000 on new dam, flume, and ditch con-

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struction. M. McColman is engineer in charge.

Fresno.—The Huntington and Balch interests of Los Angeles have purchased the power plants at San Miguel, Paso Robles, San Luis Obispo, Arroyo Grande, and Santa Maria. The price paid is said to have been $1,000,000. A power-transmission line is to be built from Coalinga to Stone Canyon.

Tonopah.—The plant of the Nevada Gas Co. was destroyed by fire on March 8, with a loss of approximately $25,000.

Salt Lake City.—The Real Estate Association is considering the construction of a 4500-hp. hydro-electric power plant to cost approximately $400,000.

Irrigation and Water Supply

Los Angeles.—On account of poor crops, the Commissioner of the General Land Office has granted an extension of time to settlers under the U. S. Reclamation Service Yuma project.

Washington, D. C.—The *Reclamation Record* gives the following percentages of completion of the various projects of the U. S. Reclamation Service: Salt River, Ariz., 93.5; Yuma, Ariz.-Calif., 65.7; Orland, Calif., 84; Grand Valley, Colo., prelim.; Uncompahgre, 53.2; Boise, Idaho, reservoir 16.5, remainder 90; Minidoka, gravity 100, south side pumping 90; Blackfeet, Mont., Two Medicine 57, Badger-Fisher 10.8; Fort Peck, no work; Flathead, Jocko 84, Mission 10.7, Pablo 34.2, Polson 9.9, Post 32.9; Huntley, 96; Milk River, 12; Sun River, 85; Lower Yellowstone, Mont.-N. Dak., 95; North Platte, Neb.-Wyo., 81; Truckee-Carson, Nev., 65.5; Carlsbad, N. M., 100; Hondo, 100; Rio Grande, N. Mex.-Tex., storage prelim., Leasburg 100; Buford-Trenton, N. Dak., 38; Williston, 64; Umatilla, Ore., 83.7; Klamath, Ore.-Calif., 70; Belle Fourche, S. Dak., 92.5; Strawberry Valley, Utah, 57; Okanogan, Wash., 100; Yakima, storage 15.7, Sunnyside 8.7, Tieton 97; Shoshone, Wyo., 49.

Modesto.—The proposed bond issue of $82,500 for a new municipal water system has been approved by the voters at an election held for that purpose.

San Francisco.—The Mount Shasta Aqueduct Co. has been incorporated by C. E. Sheets, Oakland; Thos. H. Laine, Berkeley; W. H. Hawkins, J. B. Kennedy, and C. H. MacDonagh, San Francisco; capital stock, $10,000,000.

The National Irrigation Congress will meet at Salt Lake City, Utah, from October 1 to October 5.

Railway

San Francisco.—The Northern Electric Railway Co. has let a contract to Maney Brothers for grading between Marysville and Colusa. A drawbridge to cost $240,000 will be built.—The Key Route will extend its electric service to Richmond.—Gross earnings of the United Railroads for January amounted to $671,273, being a substantial increase over that of the corresponding month for 1911.—The Southern Pacific will extend its suburban lines from Berkeley to Richmond and from San Leandro through Haywards to Niles.

Sacramento.—The line of the Sacramento Southern railway has been completed to Walnut Grove and will be extended to Antioch.—The Central California Traction Co. will build a branch line to Galt.

The city trustees of Sacramento have granted a wharf franchise between P and Q streets to the Western Pacific railroad. It is said that a competing line of river steamers will be built.

San Jose.—The San Jose Terminal Railway Co. will issue $1,000,000 in 5% bonds and construct a railway between San Jose, Alviso, and San Francisco.

Los Angeles.—The San Diego, Riverside & Los Angeles Railway Co. has been incorporated by William D. Peloubet and Maurice Sulzman of Los Angeles, and J. F. Scott, J. R. Carlisle, and A. M. Gaston of San Diego. Capital stock, $10,000,000.

Petaluma.—Local parties have raised $25,000 toward the construction of a new electric railroad through the Two Rock and Bloomfield valleys.

Oakland.—The Spring Construction Co. has commenced construction work upon what is believed to be an extension of the Key Route system into Contra Costa county.

Fresno.—The Fresno & Eastern railway, A. B. Dodds, chief engineer, will probably build a standard-gauge railroad into the Sierra National Forest to handle 800,000,000 ft. of timber recently ordered sold by the Federal Government.

Seattle.—Kuhn, Loeb & Co. have purchased the Bellingham Bay & British Columbia railway and the Bellingham Terminals Co. for $10,000,000.

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Stockton.—The Tidewater & Southern railway and the Tidewater & Transit railway have been merged, and the line is to be extended to Modesto. The directors are F. A. West, F. J. Wisecarver, W. G. Wallace, C. Johnson, M. D. Wood, Carl C. Brueck, J. A. Coley, B. A. Bearce, J. L. Craig, G. Schriber, Wylie W. Giffen, and Frank Helm.

Martinez.—Frank Rattan with San Francisco capitalists is planning an electric road from Minor station on the Santa Fé to Bay Point, about eight miles long.

Rights of way have been secured by the San Ramon Valley railroad from Walnut Creek to Danville.

Petroleum

FEBRUARY OUTPUT

In February the California fields produced 6,951,449 bbl., being a slight falling off from that of January. The total stock on hand March 1 was 42,060,297 bbl., as against 41,648,535 for January, an increase of 411,762. The production, compared with that of January, was as follows:

	February, bbl.	January, bbl.
San Joaquin:		
Coalinga	1,492,910	1,532,384
Kern River	909,488	960,657
McKittrick	475,093	480,458
Sunset	413,180	449,441
Midway	1,865,237	2,171,625
Lost Hills	69,111	56,096
Totals	5,225,014	5,650,661
Coast:		
Santa Maria, Lompoc, Cat Canyon	434,343	519,656
Summerland	4,350	4,350
Totals	438,693	524,006
Southern:		
Fullerton	446,520	473,223
Salt Lake	203,955	223,795
Whittier	59,080	72,071
Coyotes	85,216	116,300
Los Angeles City	31,842	36,100
Ventura County	42,741	43,506
Newhall	9,621	10,037
Totals	878,975	1,175,034
State totals	6,532,682	7,149,701

San Francisco.—Government statistics show that during January of this year a total of 125,733,469 gal. of oil was shipped to foreign countries from the seven principal ports of Baltimore, Boston, New York, Philadelphia, Galveston, Sabine, and San Francisco, comprising about 96% of the total oil exports. San Francisco was third in the list, with 17,321,278 gal., of the value of $393,385, as against 8,711,564 gal. valued at $188,466 in January 1911. San Francisco led all in exports of crude, with 8,064,000 gal., being 566,460 gal. more than all the other ports combined.—The Palmer Union Oil Co. has been sold to the Imperial Foreign Corporation of London and is supposed to have been purchased in order to assure a supply of fuel oil to the Cunard and associated steamships. These boats burn 6500 tons of English coal, equivalent to 20,000 bbl. of oil per day. The Palmer properties are capable of a production at present of 2500 to 3000 bbl. per day, and this must be increased to 6000 before full payment is made.

Los Angeles.—The General Pipe Lines Co., which was incorporated a short time ago, has applied for a franchise on the breakwater at San Pedro from the land end to a point at which there is 32 ft. of water in order to accommodate deep-draught tank steamers. The company is also contemplating the construction of a pipe-line from the Kern fields to Los Angeles. This company is incorporated for $7,500,000, and the directors are Charles W. Slack and W. J. McLean. It is supposed that the Esperanza Oil Co. is the owner of the new company, and that is controlled by Eugene de Sabla, John Barneson, and Louis Sloss, capitalists of San Francisco. The General Petroleum Co., owned by the same interests, has increased its capital stock from $7,500,000 to $50,000,000.—William B. Gester has reported that the route of the proposed pipe-line for the Guaranty Pipe Line Co. is feasible. The estimated cost, according to bids submitted to the Hope Engineering & Supply Co., is $971,095 for the section between Maricopa and Ventura, and $650,390 for the section between Ventura and San Pedro. Six pumping plants are included.—The Berkeley-Coalinga, Spokane Coalinga, and the Washington Oil companies are arranging to build a pipe-line from their properties to the Southern Pacific railroad.

Bakersfield.—A new schedule of prices has been put into effect by the Standard Oil Co in California as follows: Minimum, 35c. per

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barrel; maximum, 60c.; 18 to 20.9 gravity, 35c.; 21 to 23.9, 50c.; 24 to 26.9, 55c.; 27 and upward, 60c.—The Union Oil Co. has offered to take the entire output of the Independent Producers' Agency at 35c., which offer has been accepted.—The second unit of the Bessemer gas-compressing plant of the Pacific Gasoline Co. at Brea has been completed, increasing the capacity of the works to 2000 gal. per day, produced from 1,000,000 cu. ft. of natural gas from a well of the Birch Oil Co.—The Dome Oil Co. is installing a 60-hp. air-compressor to be used in the manufacture of gasoline from natural gas. The Union Oil Co. has placed orders for an experimental plant of the same character, to have a capacity of 750,000 cu. ft. of natural gas per day.

An organized movement is under way to find a method of protecting oil wells from infiltrating waters, and a meeting representing 75 producers was held at Bakersfield on March 9-10. The executive committee appointed consists of D. S. Ewing, Timothy Spellacy, S. Johnson, H. W. Thomas, T. H. Minor, W. H. Hill, T. M. Young, B. T. Dyer, M. J. Laymance, J. D. Spreckels, and A. J. Crites. The coöperation of W. H. Storms, state mineralogist, was secured, and steps are being taken to find an adequate means of remedying the difficulty. The committee has decided to levy an assessment of 2½c. per acre, on 130,000 acres of oil territory in the West Side fields to provide funds to carry on the work. W. N. Facker, water commissioner of Kern county, and his associates have the matter in charge.

Engineering Construction

San Francisco.—The Board of Harbor Commissioners awarded a contract to the Cowell Lime & Cement Co. for 75,000 bbl. cement at $1.64 per barrel.—The Board of Harbor Commissioners has decided to build three new docks at a total expenditure of $1,500,000. Two have been assigned to the American Hawaiian S. S. Co. and one to the Bates & Chesebrough line. Plans and specifications have been completed. There will also be built ten additional docks at an expenditure of $5,000,000, as rapidly as plans can be completed. Leland S. Rosener is engineer. Three new ferry slips are to be constructed at once; bids for two will be opened April 25.—The belt railway is to be extended so as to connect the north and south lines.

Oakland.—The city of Oakland has adopted plans for an auxiliary fresh-water fire-protection plant to cost about $4000.—F. H. Dahnke was awarded the contract for sewer construction in district No. 2 amounting to $12,432.45, and for district No. 3, $20,672.25.—Bids for construction of two apron wharves in the Key Route basin were opened March 4, and contract awarded to H. A. Graham at $27.60 per foot for one and $31 per foot for the other.—The Healy-Tibbitts Construction Co. has commenced work on the completion of the new quay wall for the city started by Hansbrough Brothers, and 50,000 ft. of lumber for this purpose has already been delivered.

Seattle.—Municipal and port district bond issues aggregating $8,725,000 have been authorized. Of this amount, $5,000,000 is to be spent for new Harbor Island terminals at once and $13,500,000 will be spent for this purpose within the next five years.

Richmond.—W. S. Farly, city engineer, is preparing plans for a new and complete sewer and drainage system.

Panama-Pacific Exposition

San Francisco.—The Exposition company has purchased the greater part of three blocks lying between Baker and Devisadero streets north of Tonquin street, formerly occupied by the Fulton Iron Works. The price paid, as stated in the deed, is $230,000. —The Committee on Buildings and Grounds has awarded a contract for the construction of a seawall along Lewis street between the centre line of Scott street and a point 150 ft. easterly from Pierce street.—A contract has also been awarded to the San Francisco Bridge Co. for filling in that part of the exposition site bounded by Webster, Bay, Devisadero, Scott, Tonquin, and Lewis streets. Approximately 1,000,000 yd. of material will be required, and the cost will exceed $200,000. —Specifications are being prepared for submission to bidders on greenhouses and lath houses to cost approximately $27,000, a service wagon-road between Fort Mason and the U. S. Transport docks, and for miscellaneous sewer construction.—March 28 the citizens approved the bond issue of $8,500,000 by the city to provide for a new City Hall and civic centre. The Exposition company will furnish $1,000,000 for an auditorium.

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Markets

MATERIALS FOR CONSTRUCTION

(San Francisco prices, March 30.)

Shapes—Angles, tees, and channels, 3 in. and under, $2.40 per 100 lb.; over 3 in., $2.25 per 100 lb.; I-beam, 4 in. to 15 in., $2.45 per 100 lb.

Bar Steel—Rounds and squares, $2.20 base per 100 lb.

Wire Nails—$2.65 base per 100 lb.

Black Sheet Steel—No. 18-20, $3.35; No. 22-24, $3.40; No. 26, $3.45; No. 27, $3.60; No. 28, $3.65; No. 30, $3.85.

Steel Plates—No. 16, $2.90; No. 14, $2.80; No. 12, $2.75; No. 8, $2.50; No. 10, $2.65; 3/16, $2.45; ¼ in. and heavier, $2.35; all per 100 lb.

Rails—Steel T, 8-lb., $2.20; 12-lb., $2.05; 16-lb., 20-lb., and 30-lb., $2.

Pig Iron—No. 1 foundry, $22.50 to $23.50; No. 1 hematite, $25 to $26 per long ton.

Coke—German Syndicate, forked foundry, $15 to $16 per long ton; average to arrive ex-ship, $13.50 to $14 per long ton.

Portland cement—In sacks, $2.25 per bbl.

Lime—$1.30 per bbl.

Fire-Brick—Imported Carr, Cowen, or Snowball, $50 per 1000; domestic Livermore, $32.50 per 1000.

Fire-Clay—$10 per ton.

OIL SHARES

(By courtesy San Francisco Stock Exchange.)

San Francisco, March 28.

Associated Oil..	$12.25	Peerless	$ 4.50
Brookshire	.60	Pinal	4.25
Caribou (new stock)	1.25	Premier	.58
Claremont	.60	P. S. Petroleum	.18
Coalinga Nat'l.	.15	Republic	.35
Con. Midway...	.02	Silver Tip.....	.90
Empire	1.07	Sterling	1.47
Enos	.03	S. W. & B.....	.20
Maricopa 36...	.51	Turner	.80
Midway Premier	.30	Union	98.00
Monte Cristo...	1.32	United Oil.....	.32
		W. K. Oil.....	2.10

CALIFORNIA OIL DIVIDENDS FOR FEBRUARY

Company.	Rate.	Amount.
Amalgamated	$1.00	$50,000.00
Caribou	0.025	8,070.30
Central	0.015	15,400.00
Claremont	0.015	7,500.00
Columbia	0.01	9,992.26
Del Rey	0.005	3,927.45
Euclid	0.005	1,750.00
*Hale-McLeod	....	14,000.00
Home	0.01	7,500.00
Homestake	0.10	1,000.00
Mascot	0.01	5,000.00
Monte Cristo	0.025	12,500.00
*Mount Diablo	0.02	10,000.00
New Pennsylvania	0.005	2,500.00
Paraffine	0.01	3,000.00
Rice Ranch	0.015	4,500.00
Record	....	10,000.00
San Francisco-McKittrick	0.10	5,000.00
Sauer Dough	0.02	4,000.00
Section 25	0.25	10,000.00
*State Consolidated	0.005	5,000.00
Traders	0.006	9,000.00
Union	0.006	183,387.50
Union Provident	....	90,767.60
United Petroleum	0.006	48,450.60
Western Union	0.01	10,000.00
W. K.	....	15,000.00
Total California		$490,245.71
Mex. Pet., Ltd., pfd.....	0.002-3	80,000.00
Grand total		$570,245.71

*Unlisted.

SAN FRANCISCO QUOTATIONS

(San Francisco Stock & Bond Exchange, March 28.

LISTED.

	Bid.	Ask.
Miscel. Bonds—		
Assd Oil 5.102	1/4	103 1/2
Bay C P 5'101	1/4	102 1/4
C C G&E 5.102	1/2	.....
C E ser A 6. 85		.....
C G & E 5.101	5/8	.....
do Un 5. 96	1/8	.....
Cal-st Ca 5.102		....
Cal W As 5 ..		98 1/2
Cen CTrc 5. ..		97
CityElec 5. 90	1/4	91 1/4
C C Wat 5. ..		100
do g m 5. ..		95 1/2
E E L A 5.101		.....
E L & P 6.105		.....
F & C H 6. ..		100 1/4
Gt W Pr 5. ..		85
H R T&L 6.105	1/2	.....
L Bch Gs 6.100		.....
Ls An E 5.100		.....
L A G&E 5.100		.....
Ls An R 5. ..		108 1/4
do corp5. ..		100
L A Lt g 5.100		.....
L A-P lc 5.105		.....
L A-P C 5. ..		101
Mar W&P 5 90		100
Mkt-st Ca 6 ..		100
do lc m 5 ..		93
MV&MT 5.100		.....
Nat Con 6. 93	1/2	.....
N R of C 6.112	1/4	.....
N Cal R 5.105		.....
N Cal Pr 5 100	1/4	.....
do Con 5. ..		94 3/8
N Elec 5.. 94		95 1/2
O G L&H 5. ..		103
Oak Tran 6.107	1/2	.....
do 5.... 105		.....
do Con 5.101		102 1/2
Oak Tr c 5. ..		98
do 5..... 89	1/2	.....
OakW g 5. 94	1/2	96
Om Ca R 6.101	1/4	.....
PacGasI 4. 89		.....
Pac G&E 5. ..		92 1/8
Pac E R 5.104	5/8	105
PacL&P 5. ..		98
do gtd 5. 99	1/2	100
PacT&T 5.100	3/8	100 1/2
P & C H 6. ..		100 1/2
P & O R 6. ..		100 1/4
Peo Wat 5. 75		75 1/4
SE G&R 5.103		.....
S D &Cuy 5 97	1/2	.....
S J L&P 5. 98	3/8	..
S F E R 5. ..		90
SFN&OR 6.101	3/4	....
SFO&SJ 5.104	3/4	105 1/2
do 2m 5. ..		97 1/2
do Con 5. ..		95
S J&SC 4	1/2	88
S B G&E 6.100	3/4	..
S R of C 6. ..		102
S P R 6'12.100		100 1/8
do lc g 5.112	1/2	..
S P BrC 6.126	3/4	127 1/2
SP 1st ref 4 ..		95 1/2
S V g m 4.. ..		95 1/4
U G & E 5.100		..
U R S F 4. 66		66 1/2
Val C P 5.101	1/8	101 3/4
Water Stocks—		
Marin Co.. 53	1/2	..
PeopW pfd 49		..
Spring Val. 64	1/4	..
Gas & Elec Stocks—		
City El p c 9		..
N Cal Pr Cn 49	3/4	51 1/2
Oro El com 16	1/2	17 3/4
Oro Water. ..		76
Pac Lt com 69		..
Street R R Stocks—		
California.125		..

UNLISTED.

Am Riv E5 97	1/2	..
Atl Cem		50
Ang Cal T.119	1/2	120 1/4
do 5		90
Bay C P 6.103	1/2	104
Blue LW 6.102	1/2	..
Ben WC 5. ..		103
C C G&E 5. 92		..
CalE gen5. 87	1/4	..
do pfd.. 70		..
C & N W 5.103	3/4	104 5/8
C O L & P. ..		95
C G Pr bds 92	3/4	93
do 5 ... 91		91 3/4
Gas Con As ..		29
Gt W pfd.. 61	1/4	..
do com. 32		35 1/2
HuntL&I 6.100		103
Kern L Co.180		..
Keswick c 6 ..		102 1/2
Key R pfd. ..		80
do com.. ..		25
Lt L&P bds 65	1/2	..
do com.. ..		89 1/2
L & P G C 6 ..		98
do dev 5. 90		..
L & A Ry. 99		104 3/4
Mut Elec 5 90		105
MW P&E ..101	1/2	..
N B D O M.300		350
Noble Elec ..		25
Nat Con.:. 13		..
do 2.... 70		73 1/2
N P C R 5. 99	3/4	100 1/4
Nat D Co 6 99	1/2	..
NatL&M 6. 99	3/4	..
Oahu R R.152	1/2	..
Ocn Shore 5 1		2
do cer		1 7/8
do nw stk ..		19 3/8
Ocn S S 5..100		..
Oak C R.. ..		20
OakTrc pfd 80		..
do com .. 30		40
Oak RR 6.100	1/2	..
Oak&A Ry. 19	1/2	..
do 5		80
Oro Dev .. 45		..
OW L&P 6. ..		105
Pac P Cem 70		77 1/2
Pac S Co.. ..		135
Pac G & E 91	1/4	91 1/2
do com .. 67		..
do 5 104	1/2	..
Peo W com 3	1/8	3 3/8
P & S Ry. 12	1/2	..
Pet & S RR ..		92 1/2
do stock. 20		..
SF&SJV 5.111	1/2	..
SF&NP 5..104		104 1/2
S P C R 4.. 92	1/2	95 1/2
Std Prt Cem ..		25
do bonds. 91	1/2	95
SF G&Coke ..		15
SFG&E 4	1/2 ..	94
S J Water.105		..
SC Prt Cem 49	3/4	54
do 6 91	1/4	91 1/2
Sis L&P 6. 90		..
S Yuba 6..105		109
Std Elec 5. 92		95
Sut St R 6. ..		98
West Pac.. 13		13 1/2
do 5 87	1/4	88 1/4
West P C.. 34	1/2	35
do pfd... ..		69
West S L. 12		..
WPG&Epfd 22	1/2	..
Yos Val R. ..		89

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Engineers' Note Book

SPEED of emery wheels should be 5500 ft. per minute at the periphery, for all sizes.

FOR calculating the tractive power of locomotives, where

D = diameter of cylinder in inches,
P = mean pressure of steam in cylinders in pounds per square inch,
L = length of stroke in inches,
W = diameter of driving wheel in inches,
T = tractive force on rails in pounds, then

$$T = \frac{D^2PL}{W}$$

MECHANICAL, electrical, and heat equivalents of 1 kw-hour may be taken as follows:

1000 watt-hours.
1.34 hp-hours.
2,654,200 ft-lb.
3,600,000 joules.
3412 heat units.
367,000 kilogram metres.
0.235 lb. carbon oxidized with perfect efficiency.
3.53 lb. water evaporated from and at 212°F.
22.75 lb. water raised from 62° to 212°F.

TO FIND the velocity of water discharged from a pipe-line longer than 4 times its diameter, knowing the head, length, and inside diameter, use the formula

$$V = m\sqrt{\frac{hd}{L + 54d}}$$ in which

V = approximate mean velocity in feet per second.
m = coefficient from table below.
d = diameter of pipe in feet.
h = total head in feet.
L = total length of line in feet.

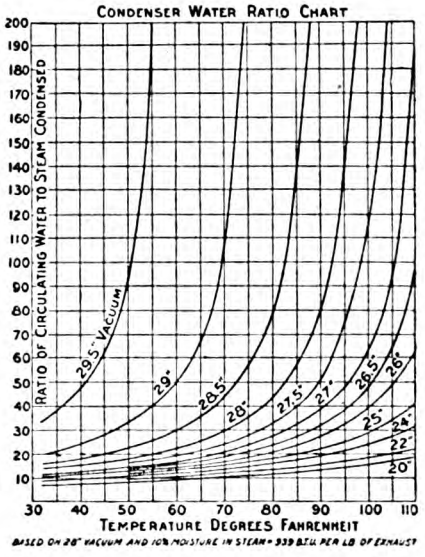
Values of coefficient m

$\frac{hd}{L+54d}$	diameter of pipe in feet						
	0.05	0.10	0.50	1.5	2	3	4
0.005	29	31	33	37	40	44	47
0.01	34	35	37	42	45	49	53
0.02	39	40	42	49	52	56	59
0.03	41	43	47	54	57	60	63
0.05	44	47	52	56	60	64	67
0.10	47	50	54	58	62	66	70
0.20	48	51	55	60	64	67	70

WEIGHT of ordinary manila or cotton rope is about $0.3D^2$ in pounds per lineal foot, where D represents the diameter in inches.

THE effect of cold rolling steel is invariably to increase the elastic and ultimate resistance. It raises the elastic resistance or shock resisting power of the material within the range of permanent distortion which is the most valuable quality of any metal intended for use in machinery where permanent alteration of form is fatal to the continued operation of the machine.

SIMPLE tables for calculating the amount of cooling water required for condensing, are valuable and convenient. That given below is furnished by the Westinghouse Electric & Manufacturing Co. The curves as drawn show the theoretical ratio of cooling water to steam condensed, assuming zero temperature difference. To use these curves



with any given temperature differences, it is only necessary to add this difference to the inlet temperature; for example, inlet temperature, 70°.; vacuum, 28 in.; temperature difference, 10°. From the curve, the water ratio for 80° and 28-in. vacuum is 44.0. Conversely, if the maximum water ratio available is known, and its temperature, the possible vacuum can be found, or having the water ratio and vacuum, the necessary inlet temperature can be determined.

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Industrial Progress

The Willans-Diesel Engine

By George Nolan.*

The advent of the Willans-Diesel engine into the machinery markets of the Pacific coast calls for more than passing interest, as its introduction means practically the revolutionizing of the present methods of making power. According to the foremost technical engineers throughout the world, the Diesel engine will, within a few years, entirely supersede the steam-engine as a prime mover, and even water-power plants cannot profitably operate in competition with it.

For years, all internal-combustion engines have been working and operating on the constant volume, or Otto cycle principle, its use being practically limited to volatile fuels and gases. Attempts have been made to use the heavier hydrocarbons in these types of engines by vaporizing them by heat, but with indifferent success. Several years ago the constant-pressure, or Diesel cycle, so-called, was invented and promulgated by Rudolph Diesel of Germany. Experiment demonstrated that it was the ideal principle to employ to convert heavy liquid fuels of the cheaper, and hence more abundant, sort into power, and this method has now been so perfected that any kind of liquid fuel, natural or artificial, can be used in this engine. It is especially adapted to use the residuum from asphalt plants, after the lighter volatile oils have been driven off. The great popularity of the Diesel engine in Europe is evidenced by the fact that over 300,000 hp. of this type has been installed during the past three years by European manufacturers operating under Diesel license. These manufacturers use the name 'Diesel' in connection with their own names to identify them as Diesel licensees, as the Krupp-Diesel engine, of Germany; the Nobel-Diesel engine, of Russia; the Willans-Diesel engine, of England; the Polar-Diesel engine, of Sweden.

At the present time, aside from the stationary plants in course of construction, over 250 vessels are on the ways in Europe and being fitted with Diesel engines, some of them as large as 12,000 hp. in single units, and as much as 2500 hp. in a single cylinder, have been developed. Contrary to all present known forms of internal combustion engine, the liquid fuel used in the Willans-Diesel engine does not explode, but simply burns noiselessly, and the expanding gases act upon the piston of the engine in practically the same way that steam acts on the piston of a steam-engine. The Diesel cycle, as used in the Willans-Diesel engine, is as follows: Commencing with the piston at the top of the cylinder, the down stroke is known as the admission stroke, and during the entire stroke pure atmospheric air is drawn into the cylinder. Note that the cylinder is filled with pure air only and not a mixture of gas or oil vapor and air, as in the Otto cycle. On the up or compression stroke, this air is compressed to about 480 lb. per square inch, its temperature, owing to the rapid compression, being raised from 60° or 70°F. to nearly 1000°F. During this stroke a quantity of fuel oil is pumped by the fuel pump into an annular space around the fuel valve. When the piston is at the top of the stroke, and the compression has reached its maximum, the fuel valve opens and fuel is sprayed in fine particles into the cylinder by compressed air, these, upon coming into contact with the hot air in the cylinder, ignite and burn almost instantly. The spraying takes place during about one-tenth of the down stroke, depending on the action of the governor which regulates the quantity of fuel delivered. The combustion of the oil proceeds at such a rate that during this period of the stroke the initial pressure of 480 lb. per square inch is maintained. During the remaining nine-tenths of this stroke, which is known as the expansion stroke, the hot gases in the cylinder expand until the end of the stroke is reached, being analogous to the action of steam in a steam-engine. The next up-stroke is the exhaust stroke, during which the waste products of combustion and burnt gases are expelled. So perfect is the consumption of fuel that the gases will not discolor a piece of white cambric if held within a foot of the point of their discharge from the engine. From this description, it will be observed that the absence of sudden rise of pressure in the cylinder eliminates shocks, rapid changes of temperature, noise, etc.; moreover, no carburetor, vaporizer, sparking or ignition device is needed, which

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does away with the sources of some of the greatest troubles and annoyances in the ordinary types of internal-combustion engines. The freedom of the Willans-Diesel engine from these troubles is, however, not its greatest recommendation. Its phenomenally economical consumption of fuel, and its conversion of about 38% of the caloric value of this fuel into useful work, as against only 12% utilized in the best types of modern steam-engines, is accountable for its rapid rise in popularity. The most carefully devised steam plants use not less than 1⅓ to 1½ lb. of fuel oil per brake-horsepower-hour, with crude oil having a caloric value of about 18,500 B.t.u. per pound.

The American manufacturers of the Willans-Diesel engine guarantee, under a definite penalty, that the consumption of crude or residual petroleum, asphalt base, having a caloric value of not less than 18,000 B.t.u. per pound, will not exceed, per brake-horsepower-hour, at full load, 0.55 lb.; at three-quarters, 0.57 lb.; at one-half, 0.61 lb.; at one-quarter, 0.75 pounds.

These figures show at a glance the superior fuel economy of the Diesel engine. Some of the other advantages for both stationary and marine purposes, are that it gives the highest known efficiency and lowest cost of power; uses the cheapest, safest, and most abundant fuel; occupies small space, is self-contained and compact; will start and take on full load in one minute; and there are no shut-downs for cleaning or repairing boilers, no danger of boiler explosions, no time or fuel is wasted getting up steam, and there are no stand-by losses. The weight of fuel carried by a Diesel engined ship is only one-third to one-quarter that necessary on a steamship. Based on fuel consumption per brake-horsepower, and with equal weight of fuel, the radius of action is increased 3 to 6 times.

The elimination of boilers, steam pipes, condensers, air and feed pumps, from a vessel, and the installation of a complete Diesel power-plant in the space ordinarily occupied by the main steam-engine makes available a large additional cargo-carrying space, which means a correspondingly larger earning capacity. Break-downs are much less likely to occur to Diesel engined ships because, instead of having the dozen or more units which enter into the power equipment of a steamship, any one of which may become out of order and stop the ship, there is only one unit, and if one or more of its cylinders should become out of order, it is possible to simply cut out the defective cylinder from the cycle of operation and run the balance of the engine the same as before, enabling the vessel to reach port with little loss of time or speed.

The economical conversion of our heavy California hydro-carbons into power is now an accomplished fact, and a great impetus should be given to Pacific Coast industries by the adoption and use of the Willans-Diesel engine as a source of power.

The Dow-Willans Diesel Engine Co., a California corporation, has purchased the sole right to manufacture and sell the Willans-Diesel engine in the United States, Hawaiian Islands, and Alaska. It is the intention of the company to build at once a completely equipped factory in Alameda for the purpose of manufacturing and constructing these engines. Pending the completion of this factory, the Diesel Engine Co. has made arrangements to have its engines constructed, under the supervision of its own engineers, at the works of the Geo. E. Dow Pumping Engine Co., and it is now ready and prepared to enter into contracts for all sizes and types of Diesel engines, for stationary or marine purposes, from 50 hp. to 1000 hp., and will make deliveries, f.o.b. cars or dock, or installed ready for operation, as desired.

Commercial Paragraphs

The Union Iron Works Co., of San Francisco, has issued a very attractive catalogue descriptive of its fuel oil-burning system using a mechanical burner. Setting plans for both marine and stationary types are shown, and valuable general data are given.

The Pelton Water Wheel Co., through its San Francisco office, has closed contracts with the Mt. Whitney Power & Electric Co. of Visalia, California, John Coffee Hays, general manager, for the complete water-wheel equipment for Kaweah plant No. 3, including two 3000-hp. units, operating under 750-hp. effective head, Pelton oil-pressure governors, Doble auxiliary release nozzles, Westinghouse 1400-kw. direct connected generators, 55-kw. single overhung type exciter generating sets. The new machinery is to be in operation by September 1, 1912.

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